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ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

HEARING

BEFORE THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON THE

REPORT OF THE SECRETARY OF THE INTERIOR TO THE CONGRESS REGARDING OIL AND GAS LEASING ON THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

JULY 22, 1987

PART 2

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ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

WEDNESDAY, JULY 22, 1987

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 2:10 p.m., in room SD-366, Dirksen Senate Office Building, Hon. J. Bennett Johnston, chairman, presiding.

The CHAIRMAN. The hearing will come to order.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, A U.S. SENATOR FROM THE STATE OF LOUISIANA

The CHAIRMAN. We are particularly pleased this afternoon to have two outstanding witnesses, I think, on this issue of ANWR, the Arctic National Wildlife Refuge, two that have with this committee, and certainly with this Chairman, very high credibility and depth of knowledge about these issues.

The problem with so much of what we do in the Senate, and ANWR in particular, is that frequently witnesses talk past one another. They will discuss the same general bill but deal with issues in a different way, so that there is never a close connection and a close focus on the issue.

We have designed this afternoon's hearing so that there will be a very close focus on the issues. And I think it is going to be very enlightening, very helpful, and very interesting to all of us.

What we have done is taken six of the principal issue areas and defined those in a general way. Those six areas are: the availability of water; two, the availability of gravel; three, the disposal of wastes and toxic materials; four, the concentrated caribou calving areas; five, the environmental record at Prudhoe Bay; and six, air quality issues.

We have drawn by lot three issues for each of our "gladiators" this afternoon. For the issues they drew, they were asked to state a proposition that they believe in, whether a negative or affirmative proposition, and then to defend that proposition. The other witness will then debate that position.

The witnesses have prepared and circulated these propositions to one another. Each witness will have five minutes to state the proposition and defend it. The other witness will then have five minutes to rebut the proposition and its defense.

There will be an additional period of two to five minutes, or longer if circumstances warrant, for surrebuttal and additional discussion between the witnesses, and that may include questions by one witness of the other witness.

After these six issues have been addressed by the witnesses, Members of the committee will then have an opportunity to ask questions. And we want to get through all six propositions before we go to the committee, so we'll have the witnesses deal fully with the issues before the committee jumps in.

Our two witnesses this afternoon are Tim Mahoney, chairman of the Alaska Coalition, representing the Sierra Club, from Washington. His name is well known to the committee, and he has done an excellent job in presenting this and other issues to the committee.

Roger Herrera is manager for exploration and lands of Standard Oil in Anchorage; has had wide experience at ANWR, as well as at Prudhoe Bay, as a geologist, and as an oil person.

And I think between these two witnesses, we'll have a very enlightening and interesting afternoon.

The first proposition relates to the availability of water for oil and gas exploration and development, and will be stated by Roger Herrera.

STATEMENT OF ROGER HERRERA, MANAGER, EXPLORATION AND LANDS, STANDARD OIL PRODUCTION CO.

Mr. Herrera. Mr. Chairman, I think it is customary at this time to say how pleased I am to be here. However, since I'm here to tell the truth, and add some truisms to the record, I have to admit that I would prefer to be in Alaska right now, especially since the silver salmon are beginning to run.

The Chairman. Well, just before they executed the last prisoner at Angola Prison in Louisiana, he said, I'd rather be fishing, too.

I hope your fate—[laughter]—I hope your fate is not as bad as his.

Mr. Herrera. I trust that remark will be struck from the record, Mr. Chairman—[laughter]—as being inappropriate. However, I can genuinely say, it is a pleasure, or it is an honor, rather, to be given the opportunity from you and your committee to address these important subjects once more.

The format that you've chosen today will undoubtedly bring some new things to light, and hopefully, will enable you to better make a decision on this subject.

Regarding water availability, which is the first six minutes—five minutes—a lot has been said about it, and I am a bit at a loss to know what to add, in that, from my viewpoint, as an oil operator on the North Slope, I look at it from a practical aspect.

What have we done? Which is worked in the past in an arctic desert where for nine months of the year there are small amounts of water around or frozen solid. And on the assumption that those things have water, which can be demonstrated for everybody to see, what cannot those same techniques be utilized, and why won't they work equally successfully on the coastal plain of ANWR if leasing takes place there.

Now, the coastal plain of ANWR does not have much free water. For two months of the year, you have limited amounts of standing water, certainly not as much as around Prudhoe Bay, because of the relative paucity of lakes on the coastal plain.

During breakup you have huge sort of outwashes of most of the melt water from the Brooks range, which rushes down to the Arctic Ocean. And for a period of about a couple of weeks, the major flow of all the rivers occurs.

The rest of the year, they carry about 10 percent of their flow, compared with 90 percent in their two-week breakup period.

Obviously it is not always convenient to utilize that short period of time when plentiful water, volumes of water, are around, especially as we are obviously hoping to operate on a year-round basis. So what do we do?

The first thing in the exploration phase, which takes place in the winter time, when there is no free water at all, and one can make the assumption, based on the responsible attitude of the state Department of Fish & Game, that free water which exists in the rivers beneath the winter ice would not be available for oil and gas activity, simply because it represents overwintering habitat of the fish, and therefore, should not be disturbed.

Likewise, the Sadlerochit Springs, which is free water in the wintertime. That is not available.

The obvious thing to do is to collect snow, which is an almost inexhaustible supply of fresh water. To show that that works, it is only necessary to go to not the examples outside of ANWR, but the one well that has been drilled within the geographical boundaries of the coastal plain and the KIC well.

That well, which is a great deep hole, 14,500 feet, took 2 years to drill; used approximately 16 million gallons of fresh water. That is a huge amount compared with an average well. A more likely exploration well in that area, which would only take one year to drill and not require two air strips, two ice roads, and so on and so forth, which doubles your water supply.

But nevertheless, three quarters of the water, more than three-quarters of the water utilized to drill that well was obtained from melting snow. It's a simply expedient of putting up a snow fence, collecting the snow, and melting it.

The other quarter, by happenstance, was able to be drawn from a deep lake which happened to be within three miles of that well location, a lake which has no overwintering fish in it, and represented one of the rare natural winter supplies of water.

That example typifies what would be done in the exploration phase. An alternative at that particular location would have been to utilize seawater which is easily desalinated and is obviously present in unlimited quantities.

This has been done many times before on the North Slope, and some of the wells drilled on the offshore spits and islands, and there is nothing magical or new about it.

So there you have two methods of producing large quantities of water, certainly sufficient for any drilling exercise which is contemplated in the exploratory phase.

Let's get to the more difficult phase of production, where you have a year-round need for large quantities of water. And quite simply, what we would contemplate to do there, is exactly what is being done at Prudhoe Bay, where the same need arises.

And that is, use water reservoirs, which are deliberately constructed for year-round supplies in the wintertime. This can be done by deepening natural lakes so that they don't freeze in the wintertime; insulating natural lakes so that they do not freeze so deeply in the wintertime; or by flooding gravel pits which have been utilized for gravel extraction to create artificial reservoirs.

All these techniques are used. All of them work. And undoubtedly they can be selected on the coastal plain of ANWR to be as environmentally benign and used again.

Water is not a problem.

["Arctic National Wildlife Refuge—Environmental Issues," submitted for the record appears in the appendix.]

The CHAIRMAN. Thank you. Mr. Mahoney.

STATEMENT OF TIM MAHONEY, CHAIRMAN, ALASKA COALITION, WASHINGTON, DC

Mr. MAHONEY. Thank you, Mr. Chairman.

Before I begin, could you explain to me what the timing in on those lights? When does the yellow light go on?

The Chairman. The green light comes on for five minutes. The yellow comes on when you have one minute left.

Mr. MAHONEY. Okay, thank you very much. Thank you for letting me be here today.

We are beginning this discussion with one of the simplest and most benign ingredients in exploratory drilling or development of an oil field: water. Nonpolluting water.

Water is in short supply in the 1002 area, short supply relative to Prudhoe Bay. It is not just the environmental community that says that. The Department of Interior says it. It is in the 1002 Report itself.

And this shortage was not analyzed. That is to say, the Congress does not have an understanding of how the water will be developed, where it will be developed, or what are the environmental impacts of the development.

Its not the environmental community alone seeing that, it's the Environmental Protection Agency that said that in their letter to Assistant Secretary Horn, and in the followup documents to that letter.

Assistant Secretary Horn, testifying before the House Merchant Marine Committee, said that EPA just did not understand, and that we would do site-specific environmental impact statements on the water problems at a later date.

But the legislation which the Department of Interior supports, and which is before this committee, S. 1217, specifically makes the 1002 reports environmental impact statement legally sufficient and requires no more statements.

In other words, we have only the word of the oil industry itself as to how the water will be developed. Mr. Herrera has discussed some of the methods of developing water.

We can use some of the lakes. But as he has acknowledged, there are not as many lakes on the 1002 area as there are in the vicinity of Prudhoe Bay. That is not such a good source.

Likewise, the rivers are small and they dry up. That is not such a good source.

So we are really talking about industry having to come to some new ideas for this, new ideas that are not made clear. We could dredge out the lakes that are existing, the shallow lakes. We could dredge out deep pools in the river.

We could mine the gravel along the banks of the river and then diver the water into those gravel pits and make reservoirs. We do not know how many. We do not know where they would be.

We do know that in this most environmentally harmless of activities, that we would have to alter the lakes, alter the rivers, and that is one of the principal habitat, say, for The musk oxen that inhabit the area year around and create new reservoirs, so that even if we were to never find a drop of oil, and there is an 81 percent chance, that we will never find a drop of oil, that is economically reasonable to develop, we would still have to make these changes to the landscape and to the wilderness.

Now, we are not talking about something that is very difficult. We are not talking about a pollutant that has not been studied. We are not talking about a complex wildlife management issue. We are talking about an engineering problem.

An engineering problem that Mr. Herrera says is a simple engineering problem. If it is so simple, then let us know where would the water come from? What streams? What lakes?

It is not just EPA that says it. It is not just us that says it. In the last week or so, we obtained, and I can make it available to you—I will refer to it several times today—a memorandum from inside the Fish & Wildlife Service.

This is a year-old memorandum in which the internal workings of the Fish & Wildlife Service is complaining that the issues before them are not being studied.

And it is the Fish & Wildlife Service that in point number five says, water will be a major problem that should be addressed comprehensively, early in the planning process, a water management plan that establishes water sources with a water distribution system should help avoid water conflicts.

Despite this early plea, we never saw it, and you still do not have it. And as far as we know, we will just have to trust the industry, which I think we can trust will do whatever is most cost efficient.

[The prepared statement of Mr. Mahoney follows:]

PREPARED STATEMENT
OF TIM MAHONEY
CHAIRMAN, ALASKA COALITION
BEFORE THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

July 22, 1987

Mr. Chairman, I am Tim Mahoney, Chairman of the Alaska Coalition. It is a pleasure to appear before the Committee today to discuss a number of issues surrounding development or protection of the Arctic National Wildlife Refuge, which have generated different explanations, or interpretations of fact, and which therefore have been particularly difficult to resolve. Following are rather lengthy discussions on each of the six topics on which we have been specifically asked to speak today.

But before we proceed to these details, let me emphasize that an examination of these details of development engineering and environmental impacts of development should not be allowed to trivialize the basic issues: should the United States irrevocably develop and thus destroy the heart of the last undisturbed wilderness on our country's Arctic Ocean coastline; should the speculative value of unknown energy production outweigh the known value of the world's greatest arctic wilderness ecosystem; should all portions of America's North Slope be made available to industrial development; is there any good way to develop a wilderness?

To summarize the environmental impacts of what this development would mean, I have enclosed this understated summation from the Interior Department's draft Legislative Environmental Impact Statement and Resource Assessment issued in November, 1986:

> Long-term losses in fish and wildlife resources, subsistence uses, and wilderness values would be the inevitable consequences of a long-term commitment to oil and gas development, production and transportation. If producing fields were discovered, petroleum operations would last for 30-90 years. Oil and gas discovery will lead to industrial development. There will be pressure to use this area as a base to service exploration and development on the outer continental shelf, or to intertie with projected oil and gas development in the Canadian Arctic. An oil development infrastructure in the 1002 area would be an impetus to develop State lands between the Canning River and the TAPS. Infrastructure in the 1002 area would serve potential offshore or other fields, adding to the long-term industrial commitment.
>
> Oil and gas development will result in widespread, long-term changes in wildlife habitats, wilderness environment, and Native community activities. Changes could include displacement and reduction in the size of the Porcupine caribou herd. The amount of reduction and its long-term significance for herd viability is highly speculative. Geography apparently limits the availability of suitable alternative calving or insect-relief habitats for the herd. Mitigation measures can minimize some adverse effects to the Porcupine caribou herd as well as to other wildlife species, wilderness characteristics, and subsistence uses.

The listing of all of the cumulative impacts and their synergistic effects tends to make the reader forget that the first impact, whether oil is found or not, is the loss of this irreplaceable wilderness. And it is this irreplaceable wilderness which is the wellspring from which all of the other values -- wildlife, scenery, air and water quality, subsistence -- come.

The Availability and Impacts of Water Extraction

The Interior Department's draft Legislative Environmental Impact Statement (LEIS) and Resource Assessment for the coastal plain of the Arctic National Wildlife Refuge states that obtaining water for drilling and ancillary purposes poses a major engineering problem for the proposed development. The final LEIS reiterates this statement in many ways:

- "as much as 15 million gallons of water may be needed to drill one exploratory well" (page 76);
- "taking this amount of water from the water-deficient 1002 area could have a major adverse effect" (page 99);
- "the large quantities of water required for development drilling on the 1002 area are not available" (page 101);
- "the 1002 area is considerably drier than the Prudhoe Bay area" (page 112);
- annual precipitation on the coastal plain of the refuge averages only six inches (page 09);
- "specific locations and sources of water and gravel for exploration and development have not been identified" (page 75);
- "water in the 1002 area is confined to surface resources, and there are few lakes of any appreciable size"; "the rivers on the 1002 area, for much of their lengths, are dry or virtually dry during the winter, and where they do have water, fish may overwinter" (page 99);
- "if a suitable water source can be found, ice roads would probably be constructed"; "one mile of ice road generally requires about 1.5 acre-feet of water". . .which is "1.2 to 1.5 million gallons of water" (pages 76-77, 85);
- ice airstrips must be constructed to accommodate the 225-295 Hercules C-130 transport plane loads of drilling equipment, material, and fuel that is needed in the construction and drilling phase of each exploratory well; ice airstrips may be 5,000-6,000 feet long, 150 feet wide, and at least 12" in depth; 7 million to 8 million gallons of water are required for the construction and maintenance of each ice airstrip (page 76);

- "desalinated sea water and snow melting are options [for providing] water for domestic use (10,000 gallons/day) and exploratory drilling operations" (30,000 gallons/day/well), however "these sources may not be economically feasible for ice roads and airstrips" (page 80);

- "the most obvious, and probably only feasible, solution relates to gravel sources", that is, mining gravel from streambeds and creating 40-50 ft. deep pools for year-round water storage.

The comments from the Environmental Protection Agency further question the practicality of the Interior Department's full-scale development recommendation. The agency states "significant shortages [of water and gravel] are acknowledged, but the final LEIS has not presented an adequate analysis to show whether water quantity/gravel quantity are sufficient to support the recommended action." The final LEIS assumes that major adverse effects can be handled in a manner which will not result in adverse impacts to water quality and habitat.

The Congressional Research Service critique prepared for this committee suggests that "while solutions to water supply problems may be site-specific, a more thorough analysis of industrial and domestic requirements of potential water supply and associated environmental impacts is needed for informed decision-making."

The Alaska Coalition believes that the Interior Department assessment is inadequate in its analysis of water supply and the effects extraction will have on water quality and quantity and on fish and wildlife populations.

Gravel Extraction

In the Prudhoe Bay industrial area to date, the oil industry has extracted over 60 million cubic yards of gravel. If there are 90,000 football fields in this country, then the gravel the oil industry has scraped from the North Slope could cover each field three feet thick in gravel.

Gravel would be used for these purposes, according to the Department of Interior's draft LEIS:

- For one exploratory well over a multi-winter drilling project, the amount of gravel needed is 35,000 cubic yards. This for only one well. (Year-round exploratory drilling would more likely be the case. As the draft Resource Assessment on page 100 notes, "From a technical and economic standpoint, industry may prefer to drill exploratory wells deeper than 15,000 to 17,000 feet on a year-round basis, not during the winter only. The impacts of year-round drilling would be similar to those for development drilling but would be more widespread throughout the 1002 area.")

- In the development phase, or even later stages of exploratory drilling, a conservative estimate of 15-55 drill pads would be about five feet thick, cover 20-100 acres, and require 180,000 to 900,000 cubic yards of gravel. The numbers here are conservative because Prudhoe Bay and surrounding fields have drilling wells that number 500-600, with 40 wells per pad.

- Up to 300 miles of roads would be necessary to service the industrial development. Roads in the arctic are approximately 35 feet wide with a thickness of five feet. The amount of gravel needed per mile of road is 40,000 cubic feet. For 300 miles of roads, this amounts to 12,000,000 cubic feet of gravel.

- Five or six airstrips need to be built. The typical airstrip is approximately a mile long, 150 feet wide, and 35 feet thick. The Resource Assessment contains no estimate of the amount of gravel used in constructing airstrips. Obviously, it is substantial.

- The Department of Interior also does not estimate how much gravel would be needed on which to place central processing facilities, marine ports, housing facilities, and other attendant developments.

If the coastal plain were leased, the subsequent oil development, extraction, transportation corridors, central processing facilities, housing facilities, port sites, and other associated developments could result in 5,000 acres actually being covered by gravel. This may not seem very extensive in a 1.5 million acre area, but the impact is not limited solely to the covering of tundra with gravel, as the oil industry would have us believe. From the final EIS:

> Physical disturbances such as erosion and sedimentation, thermokarst (caused by the melting of ground ice and settling or caving of the ground surface so that pits, hummocks, and small ponds result), impoundments, clearing, gravel spray, dust, snowdrifts, and pollution incidents would alter the habitat values of many more acres. (draft Resource Assessment, p. 103)
>
> Gravel, dust, and changes in snow accumulation patterns would affect areas surrounding petroleum development facilities. As summarized by Meehan (1986): 1) gravel spray may be deposited as far as 100 feet on either side of roads; 2) heavy dust may be deposited within 80 feet and some dust up to 250 feet out from heavily traveled roads; 3) some dust will be deposited within 160 feet of lightly traveled roads.... Therefore, approximately 7,000 acres of existing vegetation could be modified by these secondary effects.

This still does not characterize all the impacts of gravel extraction. The draft LEIS notes that the infrastructure required to develop the economic prospects of the coastal plain would involve the "mining and use of as much as 50 million cubic yards of gravel from within the 1002 area." (p. 101) If the oil industry is correct in touting these fields as possible Prudhoe Bay sized deposits, at least as much gravel would be needed as has been used at Prudhoe Bay and surrounding areas. In other words, we could again cover 90,000 of the country's football fields with an additional three feet of gravel.

> Gravel can be excavated or mined
>
> from inactive streambeds, but additional pits would have to be opened to obtain the large quantities of gravel required for roads, pump stations, airports, and maintenance-support facilities. Gravel might have to be mined from upland sites, river terraces, streambeds, lagoons, or other potential sites. (draft LEIS, p. 84)

State permitting agencies allow the oil industry to mine for gravel primarily from upland areas in the Prudhoe Bay region. Here's what the Department of Interior has to say about mining gravel from upland areas:

> The most disruptive and the most visually displeasing (for thousands of years) places from which to obtain gravel are the upland areas. (draft LEIS, p. 100)
>
> In upland areas, vegetation would be lost in the area of the borrow site, the area covered by overburden, and an area affected by erosion. Gravel removal in upland areas would be the most visually disruptive and would be extremely difficult to rehabilitate to pre-project natural conditions. (draft LEIS, p. 103)

But it is true that because of the enormous quantities of gravel that would be needed for such massive industrial development, other sources of gravel would be required. The Department of Interior suggests that mining for gravel at as many as 15 different locations, covering an area of 500 to 750 acres. Additionally, industry would have to gouge 20 to 30 deep holes for use as borrow sites along river beds -- riparian habitat which, coincidentally, happens to be extremely critical for overwintering fish and for year-round resident muskoxen.

The bottom line is this statement contained in the draft (and, somewhat surprisingly, the final) LEIS:

> The availability of adequate gravel supplies on the 1002 area is uncertain.

What is certain is that if the amount of gravel necessary for industrial development on this scale is taken from the coastal plain of the Arctic Refuge -- and it will be taken from there if the extraction of any oil from the coastal plain is to be economical -- then there will be direct and devastating impacts to the habitat of the nation's most biologically productive portion of the entire arctic coast. Likewise, though the oil industry shies away from admitting or acknowledging it, the visual intrusion of miles of roads, large production facilities, marine ports and airports, and miles of pipelines connecting hundreds of wells will be far worse on the only undisturbed arctic ecosystem in the country.

Hazardous Waste Issues on the North Slope

The North Slope of Alaska can fairly be described as a Superfund site waiting to happen. The best example that this could very well be the case in twenty years is in the area of solid waste disposal. But the problems associated with hazardous waste are not limited solely to the disposal of solid waste. Drilling mud pits, sewage treatment practices, and road watering are all activities which contribute to the hazardous waste problems.

With any industrial development, generation of hazardous materials is a given. The oil and gas development which is now occurring on the North Slope of Alaska is no exception.

Wastes Generated from Oil Extraction Process

The majority of extraction wastes are drilling muds and cuttings. Drilling muds are materials used to lubricate the drill bit and perform other functions to facilitate oil drilling. Each well on the North Slope generates annually approximately 15,000 barrels of waste muds and 3,000 barrels of waste cuttings. The approximately 300 reserve pits on the North Slope each can hold up to 13,500,000 gallons of fluids. Because of these enormous volumes, drilling wastes pose special disposal problems.

Drilling muds are principally composed of water, barite, bentonite, lignosulfonates, lignites, and sodium hydroxides. Additives to drilling muds include biocides, deflocculants, degreasers, and acids. Waste drilling fluids can contain toxic components; analyses of waste drilling fluids reveal an array of heavy metals in high concentrations. The list of chemicals is frightening: aluminum; barium; cadmium; chromium; copper; lead; nickel; selenium; and zinc. Additionally, the drilling muds have been shown to include benzencs, napthalenes, and phenathrenes -- substances which are known carcinogens.

EPA currently is studying these components and is considering their potential for designation under the Resource Conservation and Recovery Act (RCRA) as hazardous wastes. Regardless of their known or suspected toxicity, however, drilling muds are currently exempt from RCRA regulation. This stems from an amendment to RCRA uniquely associated with oil and gas production that passed in 1984. The Alaska Coalition hopes the study by the EPA results in a recommendation to Congress that these wastes should be classified as hazardous, but until then these materials are treated almost as if they are benign to the environment.

Current waste disposal practices for drilling fluids are a glaring example of irresponsible waste management by the oil and gas industry. The oil industry employs disposal practices which routinely allow known toxic wastes to escape into the environment. Concern about these shoddy practices prompted the Department of Environmental Conservation to impose new solid waste regulations. The agency and the Alaska Coalition hope that the stricter controls required for disposal of drilling mud wastes will result in better practices being adopted by the oil industry.

Currently, though, drilling wastes are stored in reserve pits -- open pits sitting out on the tundra adjacent to the gravel drilling pads. Despite stipulations contained in Alaska oil and gas leases and U.S. Army Corps of Engineers Section 404 permits that require impermeability, these reserve pits generally are not lined with plastic or other material to prevent seepage. Consequently, these contaminated materials are known to leak pervasively.

These pits are left open, and consequently receive snow and rainfall, oftentimes in sufficient volumes to result in overtopping or breaching of the contaminated materials. This results in the contamination of water sources nearby the pits. The Fish and Wildlife Service has field notes from July 26, 1983, which document that reserve pits on Drill Site 3 breached into Big Lake. Big Lake is the drinking water supply for the living quarters at Deadhorse, the main service establishment for Prudhoe Bay.

The Fish and Wildlife Service has only recently begun to study the effects of these materials escaping into the environment. Investigations have centered on water quality and the freshwater macro-invertebrate community of tundra ponds. The final LEIS states:

> Preliminary results of the investigations show significantly higher alkalinity, hardness, and turbidity in ponds adjacent to reserves pits than in control ponds (R.L. West and E. Snyder-Conn, unpublished data). Significantly higher levels of heavy metals such as nickel, barium, chromium, and arsenic were found in ponds receiving effluent that in control ponds. There were also decreases in total taxa, taxa diversity, and invertebrate abundance in tundra ponds associated with reserve pits. Introductions of barite may have physically smothered benthic organisms as well as benthic stages of other organisms. The quality and quantity of organisms used as food by North Slope bird species may be decreasing with deterioration in water quality. (page 112, emphasis added)

Probably the most astounding means by which this waste material finds its way into the environment is the intentional and voluntary practice of using reserve pit fluids for dust suppression on roads and other gravel developments. Volumes discharged in 1986 amounted to 16,000,000 gallons directly onto the tundra and 34,000,000 gallons for road watering. The extent of the problem is detailed in the section discussing impacts from gravel, but dust contaminated with these toxic substances can be dispersed up to 250 yards from roads and other gravel developments. This problem has not been studied extensively, yet the Fish and Wildlife Service notes:

> Possible effects of watering roads with reserve pit fluids are adverse impacts on invertebrates and on acid-loving plants. This could eventually affect grasing mammals and/or waterfowl and other birds. Inasmuch as the 1002 area is considerably drier than the Prudhoe Bay area, it is more likely that reserve pit fluids could be used on roads, because other local water sources are limited. (final LEIS, page 112)

Waste Oils

The oil industry disposes of oily wastes (waste oil, gasoline, and other hydrocarbons) without obtaining the necessary permits from the regulatory agency, the Alaska Department of Environmental Conservation. In 1986 alone, the Atlantic Richfield Company received from the State two Notices of Violation for oily wastes that were found leaching from waste disposal sites that were not permitted. The State prohibited further disposal of oily wastes at these sites, but took no additional legal action against the oil company because of low budgets and no permanently assigned legal help from the State Attorney General's Office.

Solid Wastes

As if the cumulative effects of improperly designed reserve pits, drilling fluid disposal practices, and problems with oily wastes were not enough to allow for a fair characterization of the Prudhoe Bay area as a Superfund site waiting to happen, then certainly the problems associated with solid waste disposal qualify this characterization.

To give an idea of the quantity of solid wastes that can be generated, let's use the example of a three-year construction project for an oil pipeline such as the trans-Alaska pipeline. Such a project would see junked over 500 destroyed vehicles, 3,000 batteries, up to 10,000 tires, up to 20,000 tons of scrap construction materials, nearly 6,000 tons of scrapped equipment components, 30,000 waste 55-gallon drums, thousands of cubic yards of construction camp wastes, and hundreds of destroyed prefabricated buildings.

The disposal of this waste has been irresponsible because the oil industry used dumps which were not permitted for all the wastes disposed. The only solid waste dump currently in operation and used by the oil industry is the Oxbow Landfill, operated by the North Slope Borough -- a local governing body equivalent to a county yet as large an area as the entire state of Minnesota. This dump was operated from 1980 through 1986 despite the refusal of the Alaska Department of Environmental Conservation to issue the necessary permits because the dump failed to meet a number of solid waste regulations.

Four other dumps were used at one time or another by the oil industry. The Department of Environmental Conservation is unsure, and in fact no one knows, about the actual number of dumps that have been used over the 18-year development period. The Environmental Protection Agency investigated these four known dumps and the Oxbow Landfill under the Superfund program because they suspected the sites of containing hazardous substances. So far these preliminary assessments have resulted in no further action by the EPA.

Another problem in the solid waste category is the generation of litter, mostly an aesthetic impact but with some associated wildlife impacts as well. High winds spread the trash over the tundra at great distances, which makes it too cost prohibitive for the oil companies to retrieve. Much of the litter is incinerated, and this can alleviate some of the problem but this contributes to air quality problems. Regardless, litter makes it into the environment.

Silly as it may seem, the Fish and Wildlife Service actually has difficulty taking an annual tundra swan census because observers sometimes mistake large pieces of littered styrofoam for swans. The Department of Environmental Conservation also has noted that birds eat littered styrofoam.

Human Wastes

Human wastes are deposited in portable waste treatment facilities, sometimes known as porta-potties. Once the excrement and other wastes have been treated in these porta-potties, the oil industry sprays this matter on the tundra or discharges it into lakes and streams. The state Department of Environmentyal Conservation calls this over-fertilized vegetation "happy tundra." The EPA has not issued permits for this activity anywhere in the Prudhoe Bay area; the only permit issued for this activity was for the Chevron well drilled in the Arctic Refuge.

Non-exempt Hazardous Wastes

As noted in the discussion on extraction wastes, the wastes associated with oil and gas production are currently exempt from hazardous waste regulations -- regardless of the toxic or hazardous nature of materials used. For example, methanol-contaminated wastes are recognized as hazardous under the Resource Conservation and Recovery Act, but if these wastes are associated with drilling operations, then they are not regulated. This allows industry to claim only minute amounts of hazardous waste, when in fact large volumes of these materials are generated on the North Slope. Under the same exemption industry is not required to report storage, transportation, and disposal of these wastes.

Industry is still required to abide by RCRA regulations for hazardous wastes generated by non-exempt activities. Included in this category, for example, are wastes generated in shops. However, due in part to wide variability in interpreting the exemption, it is difficult to assess actual volumes of hazardous wastes generated and disposed on the North Slope.

Even industry has had trouble evaluating past hazardous waste volumes. (Ad Hoc Committee on North Slope Hazardous Wastes Draft Report.) Volumes reported in Biennnial Hazardous Waste Reports have ranged from 16 million gallons in 1983 to 160,000 gallons in 1985. Information is further limited by the fact that industry is only required to submit information for every other year of operation.

Despite leniency under RCRA, the oil industry has failed to fully meet regulatory requirements for transportation and disposal of hazardous wastes. RCRA outlines a careful method for tracking hazardous wastes. Manifests, which describe hazardous wastes transported from one facility to another, must be signed by parties shipping and receiving wastes to insure accounting of all wastes. Although the North Slope oil field complex sprawls over several hundred square miles, industry never manifests wastes shipped from one oil production unit to another. Early this year -- seven years after the passage of RCRA -- the EPA still had to write a letter to Standard Oil Company to remind them that these manifests are required by regulation.

Much of the hazardous and exempt wastes have been disposed by deep well underground injection on the North Slope. RCRA regulations require that the landowner of all hazardous waste disposal facilities sign permit applications. In the case of the North Slope, the State of Alaska is the landowner and oil companies are lessees. Due to a dispute over which wastes would be accepted at ARCO's deep well injection facility, the State declined to sign ARCO's application. Technically, ARCO was in violation of hazardous wastes interim status regulations from 1980-1985 when ARCO ceased accepting non exempt hazardous wastes at its facility. We have no idea what the long-term efffects of injecting hazardous wastes into these oil wells will be.

Eleven of twenty-nine EPA and DEC inspections revealed hazardous waste violations. The most flagrant hazardous waste compliance problem resulted in a nine count criminal conviction of North Slope Salvage, Inc., which received over 14,000 partially full drums or drums with residual amounts. The company stored these barrels for ARCO, Standard Ohio Company, and other oil companies. Clean-up of a spill at this site recovered over 58,000 gallons of liquid. The Department of Environmental Conservation documented extensive soil and water contamination and determined the site to pose a "serious environmental and human health hazard."

Oil Spills

In 1985 alone, according to the Department of Enviromental Conservation, the oil industry reported 521 oil spills, which accounted for a total of more than 82,000 gallons of oil. Since 1973 the oil industry has reported to regulatory agencies more than 17,000 oil spills. Oil spills are an invevitable side effects of oil and gas development. They are unavoidable.

Here are excerpts from the Department of Interior LEIS:

> Diesel fuel is highly toxic and kills all plants on contact; it may penetrate deeply into soil, killing roots and rhizomes and remaining toxic for decades. (page 115)
>
> Direct contact with oil often results in immediate damage to above-ground vegetation. Injury to the root system may not be immediately obvious, but can cause a slow deterioration of plants and a high degree of winter kill in future years.

If oil and gas development is allowed to proceed in the Arctic Refuge, oil spills are guaranteed to result in substantial environmental damage. Again, the question we ask is whether this damage is something we are willing to allow in the gem of all our national wildlife refuges.

Air Quality

"Data on air quality in the 1002 area have not been acquired."

This revealing, somewhat disturbing, statement comes from a report detailing six years of studying the Arctic Refuge coastal plain's resources and of assessing possible impacts that would result to the environment from the development of potential undiscovered oil and gas supplies.

The Environmental Protection Agency commented on the Interior Department's final LEIS, and had this to say about the discussion of air quality:

> The final LEIS does not adequately assess primary and secondary air quality impacts. Secondary air quality effects (e.g., arctic haze and acidification of tundra) may result from upset situation and normal low level emissions even if standards are being met. Impairment of visibility is a potential impact where there is increasing concern relative to existing north slope emissions sources. (Russell to Horn, correspondence, June 1, 1987)

The problem of lack of information, therefore, is only one important facet of this pollution concern. The secondary effect of arctic haze is dismissed by the Resource Assessment and the oil industry as being caused by northern European development. Acid deposition (rain and snow) likely is causing the acidification of tundra and lakes, but is shrugged off by the industry because they contend wind conditions dissipate the harmful pollutants, despite no studies to demonstrate their implication that this renders pollution harmless. These cumulative effects have been completely ignored and unstudied.

Unfortunately, the rate of studying these impacts is not keeping pace with the hasty development now occurring in the world's arctic regions.

Some data from the Prudhoe Bay industrial development have been collected by the oil industry during two year-long periods out of 18 years of development and extraction. No on-going air monitoring program had been initiated by either government regulatory agencies or the oil industry until 1986 -- nearly 18 years after oil had been found.

If the Alaska Coalition were to base its arguments about the lack of need for additional oil reserves on two of the last 18 years of national energy consumption figures and world supply estimates, we would be laughed out of the hearing room. Yet, the oil industry is doing exactly this when they claim that no air pollution problems exist because in the two years for which data was collected by oil companies the industrial activity on the North Slope fell within the National Ambient Air Quality Standards for all pollutants.

The Environmental Protection Agency notes in a letter dated June 1, 1987, the deficiencies of the final LEIS:

> Air quality: Available knowledge of Prudhoe Bay development effects was not utilized, evaluation is deferred to future analyses.

Pollutants generated by the oil industry include nitrogen oxides, ozone, sulfur dioxide, hydrocarbons, carbon monoxide, and air toxics (e.g., airborne heavy metals and carcinogens). The following table lists emissions of various pollutants during one of the testing periods.

TABLE 1

North Slope A.K Emission Estimates (tons/year)[1]

	NO_x	SO_2	CO	HC	PM
Prudhoe Bay Unit	52,118	181	12,276	3,200	1,802
Kuparuk River Unit	12,926	84	2,564	47	340
Lisburne Development Unit	2,203	257	624	15	88
Endicott Development Unit	6,355	78	1,200	726	120
Milne Point Project	766	18	139	165	16
Total:	74.368	618	16,803	4,153	2,366

Source: ARCO, 1987(b)

Nitrogen Oxides

The industrial activity in the Prudhoe Bay region spewed 74,000 tons in one year into the air, according to the above table supplied by ARCO. For a comparison, the city of New York emits 191,000 tons per year of nitrogen oxide. The amount of this particular pollutant emitted as a result of the industrial activity on the North Slope of Alaska amounts to fully 39% of the pollution of this large U.S. city, or as much as the entire State of Maine.

If oil and gas development were permitted in the Arctic Refuge, and development is on the scale of Prudhoe Bay, then we could expect an equivalent amount of pollution -- or another 74,000 tons -- to be dumped into air as pristine as we can have it in the Arctic Refuge.

The question that needs to be resolved is whether it is acceptable to have this amount of pollution in our nation's premiere wildlife refuge.

In order to answer that very important question, we must have the information necessary to understand how severe the damage may be. We do not at this point have any information on acidification of tundra and lakes in the sensitive arctic as a result of acid deposition.

Sulfur Dioxide

Species of fruticose lichens are widespread across the tundra of the Arctic Refuge and important food for caribou. Lichens are at the base of the food chain. These lichens are extremely sensitive to increases in this pollutant, and may be affected adversely by amounts that are far less than allowable limits. U.S. Fish and Wildlife Service botanists are very concerned about long-term impacts to this food source.

Black Smoke Incidents

Black smoke incidents occur when a new field is brought into the extraction phase. The heavy butanes and propanes on top of the deposit are flared before the oil is pumped into a pipeline. In 1985, the Alaska Department of Environmental Conservation, the state environmental regulatory agency, received over 150 black smoke reports.

Imagine a neighbor two houses down burning a pile of old tires. The smoke that rises from such combustion is black and extremely odoriferous -- such an event would not endear this neighbor to many in the neighborhood.

Now imagine such burning ten times that scale, with dirty plumes stretching for 50 to 100 miles across the horizon all the way to the Arctic Refuge. Oftentimes this type of flaring lasts for more than a month. Black smoke was emitted over a 37-day period during the start-up of ARCO's Lisburne development during late 1986 and early 1987.

Such incidents result because the oil industry fails to use the available control technology. We're told that the environmental manager of ARCO Alaska, Inc., said, "For a lot of money, we could eliminate the smoke, but for a condition that typically lasts only 30 to 60 days, I'd say that's a waste."

Someone who has spent a chunk of their savings and vacation time to visit the wilderness of the Arctic Refuge does not want to see a huge plume of black smoke the entire raft or hiking trip because the oil industry thinks it's a "waste."

Recreational and wilderness aesthetics are as important in the Arctic Refuge as they are in the Grand Canyon, where no one would accept a plume of black smoke rising above the rim of the canyon. But we are not sure what is in the black smoke and whether it is harmful or not.

Total Suspended Solids

Standards for this air pollutant, mainly airborne particulates, was at the allowable limit or exceeded the limit seven times during a six-month period. These exceedences occurred during the summer months when the growing season is critically short. Much of this particulate matter originates from the gravel pads, roads and airstrips. Dust suppression usually involves spraying waste fluids from reserves pits, a questionable practice that will be covered in the section of this testimony discussing waste practices.

* * *

The chances of significantly harmful effects from air pollution at first glance would appear to be low because the oil industry met the National Ambient Air Quality Standards for Prevention of Significant Deterioration for two of the 18 years records have been taken. But we still know appallingly little about cumulative effects that contribute to arctic haze and effects of acid deposition on the tundra and limited water resources.

More important, however, is the question of whether we are willing to permit the amount of pollution that inevitably does result from industrial activity to damage the spectacular gem we have in the Arctic Refuge.

The Effects of Petroleum Development on the Porcupine Caribou Herd

The draft LEIS concluded that oil development could have a major negative impact on the 180,000-animal Porcupine caribou herd (PCH), that mitigation is not possible in the herd's core calving area, and that full-scale petroleum development could result in up to a 40% decline in the population. The final LEIS concluded that there would be major effects on the PCH from leasing and development, primarily as a result of loss and/or avoidance of a significant percentage of calving and insect-relief habitat. Increased predation, human disturbance, and higher winter mortality are also cited as the probable effects of displacement by development.

The final LEIS eliminates a "core" calving area, but acknowledges the existence of a "concentrated" calving area and states that development within this "concentrated" calving area (i.e., "in the southeastern part of the 1002 area" and "the Upper Jago River") would have a substantially greater adverse effect on the PCH than development elsewhere. In a recent report (August, 1986) issued by the Fish and Wildlife Service in preparation for the 1002 assessment, fourteen wildlife biologists from several federal and state agencies agreed that caribou density is readily apparent between "core" (50 caribou/sq.mi) and peripheral calving areas. With one exception, Scott

Robertson of ARCO, the scientists recommended this "core" calving area be deleted from the area to be leased and developed.

Based on the best scientific research and information and the aforementioned Fish and Wildlife Service report, the Alaska Coalition believes that the effects from petroleum development on the Porcupine caribou herd would be far greater than the final Interior Department report predicts.

Conservationists' primary concerns are:

- Loss of calving habitat would be the major contributing factor to population decline. Studies have shown that parturient and postpartum cows accompanied by calves are intolerant of stressful surroundings and seek areas of little or no disturbance (Cameron, 1983). Cameron concludes that "intensive oilfield development may result in virtual abandonment of areas previously occupied during calving."

  Observers reported that some calving occurred at Prudhoe Bay before the development began (Child, 1973); however, later studies (1976-85) indicate an absence of calving in the area (Cameron and Whitten, 1979, 1980, 1985).

- Specifically, calving and feeding habitat would be lost by covering drill pads, approximately 20 to 35 acres in size, with 5 feet of gravel. However, the visual impacts of pads with derricks would be far greater. Dau and Cameron (1985) report a two-mile (3 kilometers) sphere of influence around development -- an area avoided by caribou during the critical calving and post-calving period. The Interior Department estimates that 50 to 60 drill pads would be constructed on the herd's calving grounds. If the caribou do in fact avoid each of these pads as the research indicates, an enormous amount of calving habitat (303,000 acres within the 1002 area) would be lost. To make matters worse, the Alaska Department of Fish and Game believes that "the numbers of drill pads and material sites are greatly underestimated" in the final LEIS.

- The final LEIS states that disturbance from roads, pipelines, aircraft, construction, noise, and the presence of humans is unavoidable. Wildlife biologists agree that development would result in displacement of the PCH from its principal calving and mosquito-relief habitat. However, the final LEIS states that the dramatic increase in population of the CAH indicates that displacement has had no significant adverse effect on the herd and implicitly concludes that the proposed 1002 development will have no major effects on the PCH.

We believe this conclusion is the fundamental flaw in the Department's assessment of the effects of development on the PCH. The report clearly states that there is no evidence that the Prudhoe Bay area was ever concentrated or highly preferred calving habitat for the CAH. Thus the CAH has not been displaced by the Prudhoe Bay development to areas of reduced habitat value or increased predation. The PCH would be displaced to diminished habitat and would be subjected to greater predation and hunting pressures.

Therefore, a more logical conclusion can be drawn that the PCH would be significantly adversely affected by the development and a reduction in the population of the herd would be the end result.

- The loss of insect-relief habitat, particularly in coastal areas, is also greatly understated. While the report does admit that nearly 80% of the coastal insect-relief habitat could be affected if development proves to be a barrier to movement, it ignores the fact that research indicates that linear developments, such as the proposed east-west road and elevated pipeline bisecting the 1002 area, have the lowest crossing success rates (Shideler:ADFG Technical Report No.86-3, pg. xi, No. 12). Smith and Cameron (1985) found that "large, mosquito-harassed groups of caribou do not readily cross beneath elevated pipelines." They found that many animals walked or trotted parallel to the pipeline for long distances ("deflections of up to 20 miles have been observed"), "result[ing] in a substantial increase in energy expenditure." These authors expressed concern that if this unproductive activity is repeated several times during the summer, as it surely would be in the case of the PCH, it "would result in a net decrease in fat accumulation . . . during the [crucial] midsummer period of rapid growth and fattening." These changes in energy status and the associated stress could have serious implications for the winter survival rate for these animals and adversely affect the long-term health and viability of the herd.

- Numerous researchers have reported that vehicle and aircraft traffic, noise, people, and general activity is more disturbing to caribou than merely the presence of roads or structures. The 1002 report asserts many of the adverse affects from development but seems to ignore the effects 6000 people are going to have on the herds, especially during the critical calving phase of the life cycle.

- The LEIS emphasizes that comparisons between the effects of Prudhoe Bay development on the CAH and proposed oil development on the PCH must be drawn with caution. This is an understatement. The CAH population is approximately 15,000 animals, the PCH is 12 times larger with a population of 180,000 animals.

Because the Brooks Range is much further from the sea in the Central Arctic, the CAH has 5 times the displacement area as the PCH. The CAH is a year-round resident herd of the Central Arctic and, except for the pregnant females, and cows with calves, the animals have become habituated to much of the oilfield development. The PCH migrates more than 300 miles from their wintering area in the Ogilvie Mountains of the Yukon Territory to calve and nurse their young in the coastal plain of the Arctic Refuge. The PCH is unlikely to habituate to 1002 development for two very important reasons: 1) the PCH is in the most sensitive stage (calving) of their lifecycle when they arrive on the coastal plain and 2) the herd would encounter the oilfield development once a year during a critical six-week period.

The Environmental Protection Agency substantiates our concerns in their comments. The agency states that the Interior Department has likely underestimated the impacts of development on the PCH by selectively choosing data from the CAH and drawing conclusions which are not based on all the available information (e.g., Final Report Baseline Study).

The Effect of Development on Other Wildlife Species

The Interior Department final LEIS report also dramatically understates the threat oil development poses to other species of wildlife in the Arctic Refuge. For example, the draft LEIS concludes that full-scale oil development would have a major adverse impact on the nearly 600 muskoxen that reside on the coastal plain, resulting in the possible loss of 50% of the population. Habitat loss and direct mortality would have a major adverse affect on the snow geese population, a species that is already declining in numbers. The draft LEIS predicts the average number of snow geese using the 1002 area for fall staging could be reduced by nearly 50 percent. With an average of 105,000, and as many as 325,000 birds staging in the area, this is a reduction of 52,000 to 162,000 geese.

Polar bears, a circumpolar species also in decline, would lose two of three known concentrated denning areas within the 1002 area to development such as port facilities and desalination plants, vehicles, human intrusion, and noise during critical phases of the animal's life cycle -- denning, birthing and nursing. The final LEIS concludes that the Beaufort Sea population could not sustain an increase in mortality because the death rate is already equal to the birth rate, yet states that development in the refuge would have an adverse effect on the species. In reaching this conclusion, the report assumes that similar intensive development will not occur along the entire northern coast of Alaska and Canada. This assumption ignores the fact that, outside of the refuge, the entire Arctic coastal plain shoreline and outer continental shelf in Alaska are open to leasing and development. Petroleum development is also occurring east of the refuge in the Mackenzie River delta region of the Northwest Territories. The cumulative effects of current and future oil development could virtually eliminate the polar bear in the United States.

The Interior Department LEIS estimates that five to ten wolves (Weiler and others, 1985) seasonally use the coastal plain of the Arctic Refuge and the Alaska Department of Fish and Game (ADFG) has documented as many as 27 adults and seven pups in the northern portion of the Arctic Refuge in late summer 1984. Both agencies report high mortality in North Slope packs due to hunting, aerial hunting, and disease (e.g., rabies). It is generally acknowledged that wolves have been eliminated in the area around the Prudhoe Bay complex. Yet the report concludes that full-scale petroleum development, along with 6,000 people moving onto the coastal plain of the refuge, would result in only a "moderate" decline in the 5-30 wolves that use the 1002 area. Based on the Prudhoe Bay experience and research findings in Yellowstone and other ecosystems, we believe this is a totally indefensible statement.

Wildlife scientists report the wolf populations on the North Slope are considered low compared to their abundance prior to intensive aerial hunting and predator control (Weiler et al., 1985). The Interior Department LEIS predicts this trend will continue due to the direct mortality (i.e., hunting) that can be attributed to development. It seems more reasonable to conclude that development would result in the continuation of a "major" adverse impact on wolves.

Almost without exception, the Interior Department has understated the impacts of petroleum development on wildlife. Furthermore the agency has failed to account for the cumulative effects of development elsewhere in the arctic/sub-arctic region of the United States and Canada. The Alaska Coalition believes the Interior Department purposely downplayed the adverse effects on wildlife to justify the agency's recommendation for full-scale leasing and development in the 1002 area.

The "Prudhoe Experience"

Make no mistake, the Prudhoe Bay complex is an industrial complex. It is not a zoo, or a wildlife refuge. It is certainly not a wilderness. Rather, it is currently 900 square miles of oil extraction and processing, and it is growing.

The area generally referred to as Prudhoe Bay is actually a complex of oil fields organized into oil production units designed to minimize costs to industry and impacts by cooperatively building production facilities. Each production unit is run by a major operator. ARCO is responsible for the eastern operating unit of Prudhoe Bay, the Kuparuk River field, the Lisburne development facility which underlies part of Prudhoe Bay, and the West Sak Pilot project which has demonstrated reserves but is mothballed from development because of low oil prices. Standard Alaska Production Company, formerly SOHIO (and primarily owned by British Petroleum), is the major operator responsible for the western operating unit of Prudhoe Bay, and the Endicott facility located on islands in the Sagavirnokyok Delta and connected to the coast east of Prudhoe Bay by a gravel causeway.

The Prudhoe Bay oil field region includes state lands onshore from the Colville River to the Canning River, the western boundary of the Arctic Refuge, as well as nearshore waters and offshore natural and artificial islands in the Beaufort Sea. This region of the arctic has been dramatically and irrevocably altered by construction of a massive infrastructure system including over 300 miles of roads, hundreds of miles of feeder pipelines, 500-600 gravel pads, 500-600 waste disposal pits, enormous open pit gravel mines, and housing for 6,000 workers. The field's central power facility produces enough energy for a city with a population of 60,000.

Most of what passes for the glowing reports of industry's record on Prudhoe has more to do with a clever and expensive public relations campaign than with the industry's real record.

Indeed, industry's record is primarily unknown since in many years, air pollution, water pollution, toxic waste practices go unmonitored, or self-monitored.

When industry has been monitored, violations have been discovered, and regulations have had to be tightened. Many of the environmental regulations and standards now in place were developed to address impacts which industry posed to the arctic environment. For example, the state's solid waste regulations were changed to address problems caused by illegal solid waste disposal associated with TAPS and early North Slope development. While the industry's environmental behavior has improved as stricter regulations were imposed, the record is still far from perfect. A recent comprehensive review of state and federal resource agency files conducted by the Natural Resources Defense Council and Trustees for Alaska found violations of regulations or permit stipulations for air quality, water quality, solid waste, hazardous waste, oily wastes, and destruction or alteration of habitat. These violations numbered in the hundreds and ranged from excursions of permit limits to criminal convictions.

The review, which is scheduled for release in early August, cautions that due to extremely limited monitoring of North Slope activities by regulatory personnel, documented violations are only representative of past problems and do not exhaustively represent all actual violations. Field presence of agency personnel was virtually non-existent through the mid-1980's although by then production was already underway and major construction projects had already taken place. The Department of

Environmental Conservation, the state agency responsible for air and water quality as well as hazardous waste conditions, only averaged 10 person days per year in the field on the North Slope through 1983.

Although state agencies have been able to increase and better coordinate field presence since 1984, personnel at all agencies commented that due to limited staff, agencies tend not to follow through with written notices or pursue potential legal actions for all discovered violations. Generally, the approach is to handle problems verbally and to issue written notices only for larger scale violations. State agencies also commented that they tend not to pursue legal action due to limited funds, the inability of small enforcement staffs to pursue individual legal actions and still fulfill other permitting and monitoring responsibilities, and the lack of state attorneys specifically dedicated to handling environmental cases. The result of this approach is that environmental problems categorized by chronic, low-level violations may not be fully documented in the public record. Examples of these problems include black smoke emissions, wastewater discharges, litter, and loss of habitat through unpermitted gravel fill and flooding associated with blocked drainages.

Documented compliance problems include:

- Hazardous waste -- See description of North Slope Salvage incident in pertinent section;
- Air -- See description of Lisburne development facility black smoke incident in air quality section. Note ARCO claims that they are not in violation, despite black smoke emissions for more than 37 days.

- Water -- Despite stipulations in state oil and gas leases and Corps permits requiring impermeability, industry continued to use reserve pits which are known to leak.

Industry also failed to prevent discharges from other wastewater storage facilities. ARCO had recurring problems with "accidental" breaching of the dike surrounding their sewage lagoon at Kuparuk Central Processing Facility-1. DEC sent ARCO a letter in October, 1984, stating that they were dissatisfied with that year's accidental discharge of 4 million gallons. DEC commented that the wastewater could have contained fecal coliform, BOD, and suspended solids, as well as oil, since it also passed through flare pits in addition to the sewage lagoon. DEC subsequently sent ARCO a letter in May 1986 complaining that the sewage lagoon had been breached for the past three consecutive years and had violated permitted discharge limits each time.

Habitat

Notices of violations have been issued for incidents in which gravel washed out due to undersizing or improper placement of culverts has filled streams, making passage by fish impossible, for flooding mine sites without first receiving approval.

Deterioration of Environmental Quality and Habitat

Although the Prudhoe Bay fields have only been in production for a decade, there are already documented studies which show that the field has caused deterioration of water quality and eliminated substantial amounts of habitat.

Studies by the U.S. Fish and Wildlife Service show that contamination caused by waste fluids discharged or escaping from reserve pits has reached hydrologically connected tundra ponds. Contamination increased with proximity to reserve pits. Associated with these increased levels of contaminants were similar gradients of decreased abundance and diversity of aquatic invertebrates. These organisms are an important food source for North Slope birds.

A study by Meehan showed that habitat for shore birds studied was eliminated by direct placement of gravel fill, flooding or other secondary impacts, and tendency of birds not to use undeveloped areas within the field. Meehan calculated that the shore bird population in the Prudhoe Bay unit of the oil field was reduced by 18%, approximately 18,000 birds relative to similar undeveloped areas of the North Slope. Meehan found that certain species appear to be more severely affected than others. For example, estimated population decreases in the oil field during the two years of the study were 60% for dunlin, 50% for red phalarope, and 35% for golden plover.

Caribou avoidance of development and human activity has been reported by numerous investigators. Displacement of the Central Arctic Herd (CAH) from historic calving grounds in response to development at Prudhoe Bay is well documented. While bulls in the CAH have demonstrated an ability behaviorally to human activities associated with oil and gas activities, maternal groups of caribou have shown sensitivity to development especially during calving. Avoidance of disturbance areas occurs even at low levels of traffic and persists for many years after the original avoidance occcurred. Maternal groups on the CAH have been shown to avoid the TAPS during all seasons, the Prudhoe Bay oil field during summer, the Spine Road-Kuparuk Road system during calving, and the Spine Road and Milne Point Road during mid-summer. Shidelar (1986) estimates that the amount of habitat directly lost in the Prudhoe Bay fields was approximately 8,000 acres as of 1983. This includes only habitat directly covered by gravel or used by gravel mine sites. He noted that this habitat loss is insignificant compared to habitat that became unavailable to caribou because of their response to facilities and human activity.

Rehabilitation

Perhaps one of the most important issues yet to be addressed by either industry or the regulatory agencies is how will the Prudhoe Bay area be rehabilitated after this intensive industrialization and who will foot the bill? The degree to which industry fails or succeeds in rehabilitation will determine the future potential uses of the area. Both state oil and gas leases and federal 404 permits require restoration and rehabilitation, but neither agency has yet to develop policies outlining what levels of restoration will be acceptable. The Alaska Oil and Gas Conservation Commission reports that there are already 326 plugged and abandoned wells on the North Slope. (Note: there may be more than one well to a pad; these are primarily exploration wells.)

In addition to the agencies' failure to develop policies, industry has failed to take appropriate steps to develop techniques. Recent papers by ARCO and Standard Alaska detailing industry sponsored revegetation work show that research is in preliminary stages, and much research is still in the planning stages. The review by ARCO's Joyce (1987) noted that results will not be available for some time due to slow development and recovery by plants in disturbed arctic areas.

Another pressing concern is whether sufficient funds will be designated for rehabilitation. In a recent 10-page memo to the Alaska Office of Management and Budget by the Alaska Oil and Gas Association, which outlined industry's opinion on lease sale stipulations that they viewed as being of "questionable validity," AOGA noted that restoration of all exploration sites would require 1.5 to 2 times the funds necessary for construction. Construction costs were given as $4 million to $11 million per site. Chevron estimated that it would cost them more than $200,000 to close out and revegetate their exploratory well on KIC lands within the Arctic Refuge. There are hundreds of reserve pits, as well as roads, pads, and other facilities mentioned previously which will require removal or restoration. Yet, the state of Alaska only bonds lessees $100,000 per lease or $500,000 statewide in addition to $100,000 per well or $200,000 statewide.

Agencies frequently comment on the difficulty of getting industry to commit to required restoration projects. The Corps of Engineers noted that:

> in light of industries' reluctance to develop and use compensatory mitigation/restoration techniques, none has been applied on the North Slope of Alaska, except to a very limited experimental extent. The technology has not been developed at present.
> (COE, 1987)

EPA commented:

> EPA's own extensive experience with the major operator at Prudhoe Bay support the Corps conclusion; rehabilitation technology for the North Slope is particularly lacking.
> (EPA, 1987)

DOI concluded that successful rehabilitation techniques have not been developed for areas north of the Brooks Range.

The Future

It is no more reasonable to judge Prudhoe Bay's environmental record over the last dozen years and extrapolate that to the future than it would be to look at energy trends in the past dozen years and conclude that prices will fall and supplies will be plentiful. Just as advocates of energy development in the region would say we must consider our future energy needs, an objective judgment on Prudhoe must consider future trends. And these trends are frightening in scale.

With world oil prices low, development is limited to four major finds. But at least another four finds in the Prudhoe Bay area have been discovered, delineated and left undeveloped--including the 30-40 billion-barrel West Sak deposit. The rise in oil prices, which has been cited as needed for any Arctic Refuge development, will first bring this series of fields on line and expand the size, scale, and environmental impacts at Prudhoe Bay. For instance, when the West Sak find and the Seal Island find alone are developed, two additional large fields will be added to the already 900-square-mile area of industrial development, with accompanying accumulation and dispersement of impacts.

Presuming that industry's economic investments in the offshore leasing program pay off, then Prudhoe will grow once again, and the marine environment will be affected as well as the land. Marine oil spills will be added to the list of items tallied under the Prudhoe experience. In just the last two weeks, industry -- despite the claims -- was unable to properly contain a spill in Cook Inlet, Alaska, of 125,000 barrels. The Coast Guard had to take over the operation and the local fishing industry, worth $50,000,000, became its first victim. With the more difficult weather and ice conditions in the Beaufort Sea, can we expect a better performance? Not likely.

Air pollution, already worsening in the circumpolar region, will continue to increase as the industrialization grows, and as industrialization spreads across northern Europe and the Soviet Union.

The Alaska Pipeline (TAPS) Corridor, regularly ballyhooed as an environmental success story, does not remain static either. Pressures mount in the state to open the Dalton Highway to public travel. Land exchanges along the pipeline show a consolidation of private land along the corridor which would be turned over to development purposes. Anyone who doubts this need only look to our past development patterns in the once-undeveloped American West.

With the expansion of Prudhoe, the addition of offshore development and the development of the transportation corridor, northern Alaska will be a far cry from the proposal of Bob Marshall in the 1930's to declare all land north of the Yukon River a federal wilderness.

Our argument to the Committee is that this future development, coupled with our knowledge of Prudhoe today, will make protection of this one last North Slope wilderness even more valuable to America and to the entire world in the future than it does now.

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United States Department of the Interior

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EXECUTIVE DIRECTION

Regional Director Gilmore: Good morning. There are a number of things that the Region needs to be aware of today. First off, between now and about the end of April there will be much discussion about budget. Keep in mind that the 1988 budget hearings for the Senate and the House are scheduled for April 8 and 9. This is the time when the conservation organizations in particular will be asking about what we requested in the 1988 budget and what we did not receive. Remember, when talking to the conservation groups that we are responsible for maintaining the President's budget.

At this point we have not received a copy of the 1988 budget book, but as soon as we do, it is imperative that we make copies of the wording that was used when we put this book forward -- explaining why we didn't need the $300,000 for environmental education on the Delta; why we didn't need $1,200,000 for Accelerated Refuge Maintenance and Management; and why we didn't need some other monies. Now, you have to recognize that even though we do need these monies, someone in the structure has said they were not high enough priority to be funded, and the language that we put together supports that position. Because the budget is now up on the Hill, it is public information. What Fish and Wildlife Service did; what the Department did; and what the Office of Management and Budget did is available to any organization that wants it. Remember, when someone asks how much money you need there is a risk when you answer by saying I need so much; and there's not much risk when you say that we have enough money to do our job. You are going to come face-to-face with this issue, and I will again remind you that you are responsible to maintain the President's budget.

Last Friday the State held hearings in Juneau on the 1002(h) area and what their position should be with regards to opening or not opening this area. There is another set of hearings this Friday and I will be attending these. The hearings are set up to discuss the 1002(h) report, but I have been lead to believe that probably the first two questions will be on the 1002(h) report and the next hundred will probably be on the land exchange. The State, and I'm not being critical of the State at all, finds itself in two different places and is having difficulty maintaining the balance. They do not wish to lose their share of oil royalties, which is 90/10, yet they would also like to be involved in the land exchange. I will be trying to add as much dimension to the land exchange as I can, so that the State can understand basically what is happening. I think these hearings can be of some help, and there will probably be many more hearings between now and May.

There will be public meetings on the Porcupine caribou agreement. I'm looking for a schedule from Wildlife, and I need this fairly quickly because this schedule may have to be modified rather drastically due to the fact that the President is meeting with Canadian Prime Minister Mulroney the first week in April. The caribou agreement may in fact be signed at that level. Since the agreement is getting a lot of consideration from the White House, we may have to schedule public meetings earlier. The public meetings will be designed to explain what the agreement is, what it does, and to answer questions. The meetings will not be to accept comments as in a public hearing.

Now, all of this links together. We move from the caribou agreement with Canada to their official comments on the 1002(h) report. Although we had some indication that the Canadians might go 100 percent one direction or the other, their comments came as a little bit of a surprise. When Secretary Horn, Assistant Secretary Recce, and I met with the Canadian government in Ottawa a week ago, their opening sentence was, "we strongly recommend that the 1002(h) area be made wilderness." They then went on from there to justify this position. Unfortunately, and somewhat our fault, there are some statements in the 1002(h) report that ended up there as a result of editing and not as a result of changes in policy, strategy or information. It was just editing basically that caused a couple of statements that may of in fact helped Canada reach the decision that they did, and a lot of other people also. I would like to speak to one statement right now because I want you to have a basic understanding of the statement that's in there which everyone seems to have pointed out. It's on page 112, and it indicates that there will be a population decrease and some population displacement of up to 20 to 40 percent among the caribou. Until the last draft there was an or between those two, and as a result of an editing change we now have a statement in there which has convinced everyone and his brother that if we have oil and gas development on the Arctic Refuge we are going to decrease the caribou populations there 20 to 40 percent. Let's face it, if that were that case development would be unacceptable, and there would not have been a recommendation for development. As a result of this, we have had to do a lot of work to figure out how we got to that point. For the record, as best that I can get all the specialists to tell me, we cannot predicate a number or an extent of any population decrease that might come about as a result of the draft scenario that is in the 1002(h) report. And I make some emphasis on this draft scenario. The draft scenario in the report shows a development that develops the entire area at once; not as an oil field might be developed - in a serial kind of development. It would hardly be reasonable to believe that they would descend on that place and develop everything simultaneously, and that's what the report analyzed. So, there are some approaches that we used in our own report, which in fact if they were true the development would be unacceptable. So, we will be in the process of rewriting, and we will be in the process of clarifying these issues that we ourselves created. Some biologists and others who know the area will say that there may be a decrease if the displacement is severe, and if the displacement and the movement may cause a drop-off in reproduction.

We have a meeting with the Director the end of this month (February 26 and 27). The first day of that meeting will be to discuss budget issues - what are the issues for the Fish and Wildlife Service in the budget arena. The second day will be a Regional Director's meeting with the Director, in which we will discuss how to better manage the Service.

The CHAIRMAN. For the surrebuttal, would you think about three minutes would be proper, or would you need more? What is the pleasure of the witness?

Mr. HERRERA. On this occasion, Mr. Chairman, that is more than adequate.

The CHAIRMAN. All right, why do we not try three minutes. And we do not want to make this too tight in form, so if you have questions you want to ask one another, go ahead and do so.

Mr. HERRERA. The comments that Mr. Mahoney made, Mr. Chairman, indicate his desire, a desire we all have, to know where the oil is under ANWR. And when you know that, you can plan exactly.

That is an impossibility at this stage. Neither the oil industry nor the Department of Interior or anybody else knows whether the oil is—or in fact, if there is any there.

So one has to discuss this situation on a much more commonsense sort of broad basis than the specifics that he desires. Those specifics are simply not available.

He's missed out one aspect, which is, if people are very concerned about the environment of creating a new lake, which I would have hardly thought was interfering with the habitat, considering the ubiquitous nature of lakes in the coastal plain in general, creating a new one for a water supply does not really adversely change that habitat, probably enhances it a little, especially if it is a deep water lake.

But if he is concerned with that, there is another solution which has been practiced on the North Slope, and works more than adequately, and that is simply to drill a water well beneath the permafrost as was done, successfully, to produce the Milne Point field, when it was producing; it's shut-in at the moment.

That water, which is not totally non-saline, has to be desalinated, but nevertheless, it is more or less an infinite source of water which is sufficient to produce an oil field anywhere on the coastal plain of ANWR, without interfering with the environment in any recognizable fashion.

So there is another alternative which solves all his problems.

The other thing I just want to say in rebuttal, Mr. Chairman, is that if Mr. Mahoney read the thick telephone directory of comments from industry and others, which were attached to the final impact statement of DOI, all of these explanations of water sources, data on potential water, are contained in those comments; perhaps not in the formal DOI section of that report, but certainly in the public comments. They are all there in the public record.

The CHAIRMAN. Thank you. Mr. Mahoney.

Mr. MAHONEY. Thank you, Mr. Chairman. I do not know whether I read all the comments. I sure read a lot of comments over the weekend in trying to learn what Mr. Herrera was going to say.

We are talking, and we have tried to frame this debate, about a unique wilderness area; the last undisturbed ecosystem on America's Arctic coast, and we believe, the greatest Arctic ecosystem, the most diverse, the most productive, in the world, an area that for the Arctic might be like the Amazon rain forest is to the tropics, or Africa's Sarengetti Plains are.

We are talking about a very special place. When EPA says that the environmental analysis is deficient, when it mentions water or gravel as being major portions of that deficiency, and then goes on to say that based on that, the recommendations must be withdrawn, or should be withdrawn, or the analysis should be done over again, what EPA is saying is that the environmental analysis presented to you to make a decision is not as good as an environmental impact statement that would be made on any oil and gas drilling proposal, anywhere in the lower 48 on public land.

Here in this most unique place, the place where we really should know the most, we have an insufficient analysis. And it is really not very reassuring to say that if I do not like one method, they have other methods, because I will not get to say what methods.

Industry will get to say what methods. And industry habitually and reasonably chooses the least expensive method that they are allowed to proceed with.

The least expensive method may not be the least damaging method. It may not be the method that has the fewest impacts long term.

On water, we are merely saying, let us see what it looks like. And we do expect a legitimate environmental analysis of this engineering problem.

The **Chairman**. Thank you, gentlemen. Why do we not move on to the other subjects, and we can then have a wrap-up at the end, if there are further comments about any particular ones.

And then the committee Members will have questions after we go through the issues the first time.

The second issue has to do with gravel and Mr. Mahoney will state the question.

Mr. **Mahoney**. Thank you, Mr. Chairman.

Our argument, in brief, for gravel, is very similar to that for water. Gravel is used for exploratory drilling purposes. Not perhaps as frequently as water or not as much as water.

It is certainly used in the development of a field, for the construction of the roads, the pipelines, the maritime facilities.

And according to the Department of Interior, it is in limited supply.

Furthermore, the extraction of the gravel will necessarily destroy the wilderness qualities on the coastal plain; it could severely alter the landscape, both in the excavation, the mining of the gravel, and in the development of a field, the development of the roads, the air strips, the pads for gravels.

The industry likes to talk about gravel—or likes to talk about exploration generally—as if this is a relatively benign activity. If you watched NBC news last week, one industry executive said, there are no environmental impacts from exploratory drilling.

Well, according to the Department of Interior, if the industry does not choose to use ice, if it chooses to use gravel for economic reasons, or for technical reasons, if industry chooses to explore wells that are so deep that they will take more time than a single winter, or industry believes they want to go back again and again, and frankly, the Department of Interior even says if industry wants to drill these exploratory wells year around, then they are going to need gravel.

How much gravel, we do not know for the exploratory purposes. We do know that the field, if there is a field, if it is developed, that the gravel could be massive. We have these facilities called central production facilities that are developed on gravel pads.

According to the Department of Interior, they could be 20 to 100 acres in size. They are five feet thick. Construction of air strips, there might be four or five of these. They are 30 acres in size for an airstrip, five feet thick, 15 to 55 drilling pads, that is another thing we do not know. That is really up to the industry, and up to the field.

They can be 20 to 35 acres in size. They are five foot thick. And roads, which are 35 feet wide, five foot thick, five acres of gravel surface to a mile.

The total, under what they call is the mean development model, not a Prudhoe Bay model, but a mean model of 3 million barrels, is 50,000,000 cubic yards of gravel.

Now, when you are at Prudhoe Bay this summer, if my information is correct, you are going to see a lot of gravel roads and airstrips and facilities, and that is going to total 60 million cubic yards.

And I am told that to figure out what 60 million cubic yards of gravel is, try to imagine 90,000 football fields.

I do not know if there are 90,000 football fields in the United States. But take 90,000 of them, and cover them with gravel three foot thick, and that is how much gravel is used in Prudhoe Bay.

And that is how much gravel that the Department of Interior just sort of blithely says will be needed here.

Now we have only got a few places to get the gravel from, perhaps from the river banks, from this river habitat, or perhaps from up in the foothills.

The industry comments talk about getting it from the foothills, an area that the Department of Interior says is the most difficult to reclaim.

Now, once again, we have no doubts that the industry can do this. We have no doubts that the industry has the technological know-how to do it.

But we have severe doubts whether the Congress has been shown what it will look like; has been given the environmental analysis; has been given a modest development plan; and has been given any information about long term impacts or reclamation.

The CHAIRMAN. Mr. Herrera.

Mr. HERRERA. Once again, Mr. Chairman, this is eminently a practical problem. And it is very difficult for me to understand why it is a problem, irrespective of whether one looks at it from an environmental viewpoint, or as a potential builder of roads and gravel paths.

It is a fact, which is represented in the Congressional Record, that during the seismic survey that was shot over the coastal plain in 1984, the methods used to get those records involved the drilling of 75 foot holes in the ground in which dynamite was put, and the dynamite sauce was the energy necessary to get the seismic records.

A byproduct of that survey was information in the top 75 feet of the soil profile across the whole of the coastal plain. There are 607 line miles of seismic shot in that year, and every 220 feet on those 607 miles a 75-foot shot hole was drilled.

That represents 14,500-odd shot holes, pieces of data, geological data, down to 75 feet.

One can look at that data, if one has the patience, and find that over 95 percent of those shot holes contained appreciable quantities of gravel, the vast majority of them gravel from top to bottom, with a thin layer of peat overburden in the top five or ten feet of the hole.

This was quite unexpected. Geologically, we did not expect this, although when you look at the terrain that you are talking about, it is logical.

You have the Brooks Range, just 30 miles to your south. The rivers flow straight northward to the Arctic Ocean. They carry huge volumes of water and erosional material for a few weeks of the year during June breakup, and of course, carry vast quantities of gravel down, and have over geological time deposited it on that flat coastal plain.

Gravel is ubiquitous across the coastal plain. There is no problem with regard to quantities. The quantities that Mr. Mahoney quoted I think are exaggerated, but let me put those into a perspective which is perhaps more real.

Irrespective of the 60 million yards at Prudhoe Bay—to my knowledge, nobody has ever bothered to calculate that—but we do know exactly how much gravel was utilized in the development of the Endicott oil field, which is the latest, newest oil field in the Arctic.

That field, which is the tenth largest oil field in North America, will come on stream in November of this year, used a total of 6.7 million cubic yards of gravel.

That involved a road, a one-road access, a causeway three miles out to sea, and then construction of two gravel islands offshore from where the field will be developed.

The actual gravel in the two islands represents a little over a million yards. The million yards of gravel, leaving aside the roads and causeway, for pads for the tenth biggest oilfield in North America.

One must not look at Prudhoe Bay field itself to get some idea of what might happen in ANWR. One must look at the latest oilfield, the state of technology in the Prudhoe Bay region, which is Endicott.

And that gives you some idea of industry's capability of utilizing less gravel for the permanent facilities that are required during the production phase.

So we are not talking about 50 million cubic yards, as Mr. Mahoney suggests. We are talking about orders of magnitude less than that.

My point is that even if we wanted 50 million yards, we know for a geological fact that that gravel is there nearly everywhere over the coastal plain.

Consequently irrespective of where we find oil, assuming we do, we can choose the most benign source of gravel within reasonable distance to that oil field, to extract and utilize the gravel.

Now, let me just mention, before I finish, how that decision is made. Gravel pits are well known, and have worked and have extracted this 60 million yards of somewhat fictional gravel that Mr. Mahoney talks about at Prudhoe Bay.

There is nothing wrong with them. They are rehabilitated. Some of them are created in the water reservoirs. And they are not blights on the landscape. They are useful.

The point is, though, that is not the operating oil company that makes the decision as to where the gravel is mined. It is as a result of a full scale environmental impact statement which involves all Federal, state and local agencies.

It is a decision made by all experts, not just the oil industry experts. Certainly, we give our opinion of where we would like to use gravel, and the reasons for any given development. But that opinion is sometimes overruled.

It is a rational decision which takes account not only of our obvious economic needs, but also of environmental requirements.

The CHAIRMAN. Thank you. Mr. Mahoney?

Mr. MAHONEY. Thank you, Mr. Chairman. We are no fans of the Department of Interior's 1002 Report. We think that even in the transformation from the draft to the final, that they often took the comments from Mr. Herrera's company and inserted them into the report wholesale. But even the final 1002 Report says that there is a problem with gravel availability. So I do not know how persuasive the industry's suggestions that there is a lot of gravel is overall, but it was not persuasive enough for the Department of Interior to retract this as a problem.

There are three aspects to the gravel problem that are difficult. We have the problem of extraction: where is it going to be, the rivers or the foothills or both? Which rivers? Which foothills? What is the reclamation?

We don't know. There is no plan.

Then there is the question of where does the gravel go. Again, 50 million cubic yard figure is the Department of Interior's figure, not my figure, and that is for the mean oilfield that they like to project out there, not the Prudhoe Bay field, but the industry likes to talk about this being a relatively small amount of gravel.

But we are talking about a maze of gravel, gravel roads going a hundred miles across this area, from port to the west end, accompanied by gravel for the pipeline, gravel side roads for the wells, gravel pits perhaps, gravel air strips.

So that if you were to fly over this area, you would see a maze of gravel, going from end to end, across the entire place. There is no way you can have development and wilderness. You are going to have a maze.

We have talked about this sometimes, Mr. Chairman, in terms of what the problem was for Congress of deciding whether to flood the Grand Canyon and use that for energy. And we have said, well, it is easy for Americans to visualize that you cannot have the Grand Canyon and have a reservoir behind it.

Well, you cannot have the Arctic Wilderness and have a maze of gravel roads.

A third aspect, and we are going to talk about this a little more, is dust. Once you put the gravel down in this desert, you have dust.

Dust flies up all the time. And dust goes dozens of yards to hundreds of yards off the roads, depending on how heavily they are travelled.

And industry takes residues from their reserve pits and sprays the dust, and then we have toxic dust that we spray around.

This is what development will look like. And we are not talking about Prudhoe Bay which is a relatively small corner of a relatively broad coastal plain, where the mountains sit way back.

We are talking about a very narrow coastal plain, where the mountains come right up to the sea. And we are talking about the absolute destruction of habitat that gets squeezed into this coastal plain, just like toothpaste in a tube.

It is very, very narrow. And the implications of this development are very, very concentrated, there.

The **CHAIRMAN**. Mr. Herrera.

Mr. **HERRERA**. Mr. Chairman, when Mr. Mahoney has the opportunity to go up to see the Arctic himself, he will know that for ten months of the year, the dust that he refers to coming off the road is white, and it is called normally snow.

If also he looks at Endicott, he will know that the maze of roads which he has in his mind in fact does not materialize in a new, modern oilfield development.

In ANWR, if a field is found and developed, it will have one road going to it. And that road will not be adjacent to the pipeline, as was necessary when the TAPS pipeline for example was built from Prudhoe Bay down to Valdez.

That pipeline was built from a gravel road. That was the only state of technology that enabled the pipeline to be constructed at that time.

The Endicott pipeline which is only 26 miles long, but nevertheless, is indicative of what would be done today, was built from an ice road in the wintertime. So was the Kuparuk pipeline.

And there is no necessity to have extra gravel roads simply to construct a pipeline.

There are many other techniques which are used now to eliminate the maze of roads that he is concerned about. We would be concerned about them too, because they are jolly expensive. They are expensive to build, and expensive to maintain, and they are a problem, certainly aesthetically, as far as the environment is concerned.

So one does everything to cut down on gravel, not enlarge on its use.

What one does with gravel pits is well established. The water supply for the Kuparuk oilfield comes out of a gravel pit which has been reclaimed as a littoral zone for wading birds and other birds and wildlife.

In fact, there is fish in that pit now.

One of the pits at Prudhoe Bay which Standard operates is presently being studied for reclamation for similar biological uses.

The point I have made before and I stick to is the utilization of gravel is one, going to be a minimum, and two, it is going to take place in an area which is accepted as most environmentally beneficial.

You do not have to wreck the environment to extract gravel. You chose the least damaging area, and then after you've taken your gravel out, you reclaim the resulting pit.

The **Chairman**. Thank you. The next issue is the disposal of waste and toxic materials. Mr. Herrera.

Mr. **Mahoney**. Is there a rebuttal to that? Mr. Chairman, I am sorry. Did we go the right number of times?

The **Chairman**. Excuse me. Go ahead, please.

Mr. **Mahoney**. I have only a couple of questions, more than statements. First of all, all of the figures I have quoted are figures that have been given to you by the Department of the Interior.

If there are different figures that the oil companies have, they are not the figures that the Department has given to you to make your decision.

If the field is going to be like the Endicott field, that is not how the Department of Interior has hypothesized it. Mr. Herrera is right, I have not been there. But I believe that the Endicott field is offshore, at least in part, and would have a very different engineering design, perhaps, than something like the 1002 area that we are talking about.

And lastly, I'm not an engineer. But it stands to read that if water is in short supply, and we are talking about digging out gravel pits to build reservoirs for water, then we might see more water used, not less, in part to make up for the water availability problems.

Thank you.

The **Chairman**. Thank you, Mr. Mahoney.

The next item is the disposal of waste and toxic materials. Mr. Herrera.

Mr. **Herrera**. Mr. Chairman, waste disposal obviously is part and parcel of any development in the arctic. This is also done in temperate regions.

This is simply because you don't have you a local infrastructure which can be used to simply collect your waste and take it away and you never see it again. You have to deal with it yourself.

And it is much more difficult to just tidy it up there than it is perhaps in many other areas of the world.

Let's divide it up into various categories, if only because different kinds of waste have to be dealt with in different physical fashions, and are guided by different laws and regulations.

Perhaps an easy one to get rid of is solid waste. Solid waste, noncombustible metals, and so on and so forth, are dealt with on the North Slope of Alaska by a local utility which is run by the North Slope Borough.

Whether the oil industry or service industry wants to do otherwise or no, it cannot by local ordinances. It cannot store its solid waste other than in the North Slope Borough facility. That's by local ordinance.

And so everyday the usual type system that you have that are familiar with down here happens. The solid waste is collected. It is taken to the former gravel pit which is now used by the North Slope Borough as a solid waste disposal.

Burnable materials are incinerated at that pit in an appropriately permitted incinerator, and the solid material is periodically buried, and in essence, returned to the permafrost in that pit, and is solidly frozen for the rest of geological time.

This has not always been the case. No doubt, Mr. Mahoney will hark back to the old days, the bad old days, as he might refer to them, although he tends to bring them into the present, which is not correct, when there was no such facility.

And there were, in fact, I think six pits on the North Slope which were used for solid waste. All those pits have been reclaimed to the extent they needed to be reclaimed, and are covered up and are no longer utilized by appropriate permit.

Hazardous wastes, obviously, are much more difficult things to deal with than the solid wastes I've been talking about. First of all, by law, oil field waste, such as the waters, the secondarily produced waters and so on, associated with the oil, is not by definition hazardous waste.

We are talking about wastes which are obviously sort of corrosive chemicals, used oils from crankcases and other things which are well defined in the appropriate regulations.

These, by law, have to be traced from the cradle to the grave, so to speak. And in this State of Alaska, there is no depository for hazardous waste.

However, one has a good control on this stuff, because you don't create hazardous wastes in the North Slope in the Prudhoe Bay oil field region. You take it in. And therefore, the less you take in, the less you have to deal with it.

In essence, in 1985, for example, Standard Oil was forced to record, deal, and store, and appropriately get rid of, 300 barrels of hazardous waste. Of that, 26 percent was neutralized on the North Slope or reutilized in some way which in essence took care of it, legally obviously.

Sixty-one percent was sent to California where it was used in a cement kiln, in essence, used as a secondary energy source and burned in that fashion. And only six percent of it had to be shipped out of state to a hazardous waste depository, in fact in the State of Texas.

So the methods of dealing with hazardous waste are well established and well followed.

Sanitary waste, another form of waste associated with a maximum of perhaps 6,000 people that one has at the oilfield in the middle of the summer, is dealt with by normal treatment plants which operate to secondary and if necessary to tertiary standards.

And in fact, the one at the Standard base camp, which is quite a large sanitary facility, is on record as being in the one percentile—the top 99 to 100 percentile of all sanitary waste facilities in this country as far as its record of compliance with appropriate regulations is concerned.

Oil field wastes such as water, mud, and cuttings and reserve pits, I think we will deal with under the Prudhoe Bay experience, which is another subject.

It is a long, involved subject, and probably is worthy of a full six minutes on its own. But basically, what we have learned over the past 15 years of being active on the North Slope of Alaska, and more specifically perhaps in the past five years of greater enlightenment with regard to waste disposal, is that these things can be dealt with more than adequately and rationally, and if one follows the rules, the end result is environmentally satisfactory.

The CHAIRMAN. Thank you. Staff has suggested that we extend both sides for another couple of minutes to talk about the drilling matter, if you would like to speak on that for an additional two minutes.

Mr. HERRERA. A lot of controversy is being generated on the subject of the waste products of drilling wells in the Prudhoe Bay field, principally drilling muds and cuttings.

The method that has been used traditionally to cope with these materials is to construct adjacent to your drilling pad from perhaps as many as 48 wells would be drilled—and in passing, I will say, that the Endicott oilfield, although it's offshore, was developed in exactly the same way as the Prudhoe Bay oilfield.

Prudhoe Bay is in essence an offshore oilfield on a wetland, permafrost tundra. So they're no different.

But the traditional way to deal with mud and cuttings has been to put them, when the well is finished and you no longer have a use for those materials, put the rock cuttings and the associated mud, which you have to store, into a reserve pit adjacent to the pad.

Over a period of time, there are over 130 such reserve pits in Prudhoe Bay today. And in the period of time that those reserve pits have been in existence, five of them have breached their banks, five, and have emptied the resultant material, or the stored material, out onto the tundra, sometimes with results which are less than acceptable.

In each case, the results have been cleaned up. The place has been reclaimed and studied thereafter and monitored, and the end results of over a period of a year or two have been a return to normality.

But nevertheless, the contention is that these materials in these reserve pits are potentially of a hazardous nature, if only because of the salt content, which obviously is anathema to adjacent plant communities; they don't like concentrations of salt. And also, heavy metals which are part and parcel of the natural materials that are put into drilling mud.

The varieties that are used as weight material in the mud contains numerous heavy metals—cadmium, copper, iron, manganese, lead and so on, and chrome.

It has been very difficult, it has proven very difficult to build these pits so that they do not leak. There are two problems. One, the contents, the liquid contents of the pit seep through the gravel walls of the pit, and it sometimes can be demonstrably seen to have affected the adjacent tundra.

The other problem that is common to these pits is that they fill up with snow in the wintertime. When that snow melts, the water level in the pit gets to such a level that it breaches the pit wall, or in fact, overflows the pit wall, and in that way, you get the contents of the pit, to a degree at least, distributed on the tundra.

Without going into the horror stories—no doubt Mr. Mahoney has learned all these himself and will tell you—let me tell you what's being done about it. Because he's talking about the past, not the future; not the present and the future.

First of all, new regulations have been established for reserve pits in Alaska, which are performance standard regulations. By law, anything that seeps out that reserve pit 50 feet from the reserve pit must be drinking water and nothing else.

How we meet that standard has been left to the operating companies, and they have different philosophies about it. What ARCO is intending to do is to rebuild the walls of their reserve pits and make them impermeable.

What Standard is doing is saying, we're going to have a hard time doing that, and it would be very difficult and expensive to do that; let's try a different technique. And our solution to the problem is to design reserve pits in a totally different fashion, only to contain cuttings, not mud.

The mud we will dispose of down a special disposal well on that individual pad, or down a well which has an annulus open, down which such material can be legally and properly disposed of. And thereby, we have no mud.

We have taken care of it in an appropriate fashion. When the pit fills up with cuttings, we top the pit off, and it is then solid land, just like the adjacent pad.

And that is how we are solving the problem. A look at that working is again seen in the Endicott oilfield. At Endicott, which is an offshore oilfield, as Mr. Mahoney pointed out to us, but which as I said is almost identical to an onshore oilfield in the arctic, at Endicott there is only one reserve pit present for 100 wells which are being drilled there, and that reserve pit is present for one reason only: for safety.

It is not used as a repository for mud or cuttings. The mud is disposed of separately. The cuttings are reinjected specially into the ground.

So reserve pits, as Mr. Mahoney will describe them, are a thing of the past. The future is much different and much better.

The **Chairman**. Mr. Mahoney.

Mr. **Mahoney**. Thank you, Mr. Chairman.

Let us start with the reserve pits, and then work our way backwards through the other ones.

When we explore for oil, whether we find any or not, we use drilling muds. And drilling muds have a lot of chemicals in them, which I have trouble pronouncing: barite, lentonite, lignosulfonates, lignites, sodium hydroxides, deflocculants, degreasers, aluminum, barium, cadmium, chromium, copper, lead, nickel, selenium, zinc, napthalenes, benzenes, phenathrenes—a lot of heavy metals, a lot of carcinogens.

They are not probably in the same concentration as you might find at a chemical plant, but they're toxic nonetheless, and they accompany each well, whether it was drilled a long time ago by the old methods, or whether it is drilled today by the new methods.

And as Mr. Herrera described, these reserve pits you will see some this summer, I am told, including one at the Chevron well near Kactovic. These pits, this soup, this toxic soup, is just put in the pit, and it is open to the air.

As Mr. Herrera described sometimes as the pits get full, they fill up with water and spill. Other times, and in the past, I guess they have not made these things very impermeable, they have leaked. Consequently, the chemicals are getting out on the tundra.

And because we are in a situation here with permafrost, the chemicals do not go straight down. The chemicals work there way along the top of the permafrost, as best we can guess, and infect the tundra, and seep into ponds throughout the area.

Now, there is a study by Mr. West and a Snyder Conn that is cited in the Department of Interior's report which appears to be the basic scientific study of this issue. And they show that the level of toxics in ponds near the oil facilities is much higher, as you might expect, than it is in wilderness ponds far away that were studied as the control.

So we have already had a problem of the escape of these chemicals. As I mentioned, in the gravel part of the discussion, that is not all that industry does.

They apply to the State of Alaska for a permit when these things, when these reserve ponds, settle out, and there is more of a watery mass on top, they apply for a permit, and they suck up this buttermilk, and go out and spray it on the gravel roads in order to keep the dust down.

Now of course they dry out, and the dust keeps flying around some more, and they spray it again.

Now the State of Alaska asked them to check this stuff for various heavy metals, for various carcinogens, and they do check it. But they tend to get the results back after they have already sprayed it.

And time after time after time, they are in violation of the State regulations, the State rules, and of course, since the dust spreads to greater length, we are going to hear of air pollution. It is a very windy place. The dust spreads. The dust, which over time becomes a toxic concentration as well, spreads out over the tundra.

Now, what does this mean? We do not know. We know that the ponds are getting more toxic. We know that the scientists believe that this is killing some of the organisms that are in the ponds.

But we also know that the waterfowl continue to come into the ponds and ingest the organisms or eat the plants that are nearby, and then fly off and they go up the food chain, as far as we know.

Well, that is the drill problem.

Solid waste: Solid waste disposal on the North Slope is very different than solid waste disposal around here. Very different from what you would find in a typical landfill.

There you find trucks and helicopters and quonset huts, and old batteries, and barrels. I have here somewhere an example of what a three-year construction project on an oil pipeline would result in for solid waste; 500 destroyed vehicles, 3,000 batteries, 10,000 tires, 20,000 tons of scrap construction materials, 6,000 tons of scrapped equipment, components, 30,000 waste 55-gallon drums, thousands of cubic yards of construction camp waste, hundreds of destroyed prefabricated buildings.

That is a solid waste site. We have had I believe in the Prudhoe Bay area five of these. None to my knowledge has ever received their proper Federal permits. Five I am told have received State permits.

There are others which have been done illegally, of an unknown number. And we currently have EPA investigating some of these pits to see whether they have toxics within them, and to see whether they may be potential superfund sites.

The question of hazardous waste came up. One of the bad old stories occurred a few years ago to the North Slope Salvage Corporation, which had something like 14,000 partially full drums, or drums of residual amounts of hazardous waste that was improperly disposed of.

These were barrels that were obtained from ARCO, Standard and other oil companies. The waste spilled. The EPA, the state DEC, were brought in to clean it up. They cleaned up 58,000 gallons of hazardous waste.

This resulted in criminal charges, and convictions. I do not necessarily believe that these are the bad old days. As industry makes mistakes on the North Slope, the agencies rush to rewrite the regs, and try to get them to catch up with what the industry is doing.

Of course industry does not take this lying down. They complain about the costs. In the EPA letter discussing mitigation, they say that the mitigation procedures discussed in the 1002 report are incomplete. They assume that mitigation measures will be both consistently implemented and completely successful.

No analyses or references are provided to support these assumptions. Rather, the final EIS states that the experience, arbitrarily states, that the experience at Prudhoe Bay provides a basis for eliminating or minimizing adverse effects.

The Corps of Engineers noted in its comments that industry has been reluctant to apply compensatory mitigation and restoration techniques on the North Slope, except in very limited experimental circumstances.

And EPA's own extensive experience with the major operators at Prudhoe Bay supports this conclusion. Rehabilitation technology for the North Slope is particularly lacking.

That is the same thing the Fish & Wildlife Service said a year ago in its own internal comments. They said, contaminants are totally ignored. In 1984, 58 million gallons of reserve pit fluid were pumped directly under the tundra at Prudhoe Bay, and that does not include the fluid sprayed on the roads.

Of 21 pits for which effluent data were reported, 20 violated the effluent standards. Waterfowl are observed in and adjacent to these pits, and oil companies are continually changing plans, depending on the economics, and frequently cite the environmental concerns as making or breaking a project.

It is only this year that the industry, in complaining to the State of Alaska about new regulations for rehabilitations say that the costs are phenomenal, that the rehabilitation of a site will cost 1.5 to 2 times the original construction cost.

Current construction costs for onshore drill site and air strip are $4 million to $11 million. Construction costs for Beaufort Sea offshore exploratory island drilling of $4 million to $100 million.

In other words, the industry does not want to rehabilitate the place. The industry has not been shown to want to rehabilitate this place.

The State, which is sorely lacking in the number of personnel that are needed to monitor it, to enforce it, come up and find out about these mistakes later.

We still do not know what is up there, and when we talk about Prudhoe Bay as being a golden experience—and I guess we are going to talk about that—there is one thing we do not know, which is, what is Prudhoe Bay going to be like in 10 years, or 20 years, or 100 years?

We believe that it is going to be a toxic area.

The **Chairman**. Thank you. I was about to forget, but will not, the surrebuttal by Mr. Herrera.

Mr. **Herrera**. Thank you, Mr. Chairman.

Mr. Mahoney was making a few of somewhat exaggerated statements, so I feel that I do have to correct some of them. Just a detail, because you I hope will be able to see this for yourself.

When you go to the Chevron KIC well, you will not see a reserve pit. There is not one there. The small safety pit that they have has been refilled and reclaimed. Reclamation is something we apparently we cannot do yet, yet you will see for yourself how successful it has been on that occasion at least.

Let me talk about the 20 violations he mentioned with regard to the emptying of water from reserve pits on the tundra. This was first contemplated in about 1984 as a solution to the breaching, or the potential breaching or overflowing of pits.

The reason it was proposed to put the water onto the tundra, because the vast volume of water in those pits is snow melt water. What we have been doing is leaving the pits untouched, adding no new constituents, for a 12-month period, allowing the water in the pit to go through a whole winter freeze cycle, during which times, when water freezes, you tend to get concentrations of salts, and they drop out to the bottom of the pit, so that an undisturbed pit, which had been lying like that for a year, tended to have a head of water on top of the mud at the bottom, which was drinking water quality.

Now we went to the State of Alaska and proposed to them that a solution to the problem would be to pump this drinking water out of the pit onto the tundra, which obviously has lots of water on it during the summer time.

The State of Alaska said, that was a great idea, but you have to monitor the water first, and every 200,000 gallons, as you pump it out, you have to monitor it again during the actual extraction of the water.

So we carried out a lab analysis of the water, ascertained it was drinking water quality, and then, when the permit was issued, the pumping would begin and the water would be put on the tundra.

Every five hours, at 200,000 gallons, a new test would be done for salt content in particular, which could be done on the spot. And as soon as that test showed that we were approaching or had exceeded the drinking water quality standards for salt, that stopped the disposal of the water on the tundra.

Thus the records show that in 20 of 21 instances, we actually exceeded the drinking water standards. And that was, in fact, the test of when to stop dumping the water onto the tundra.

There is absolutely no damage by such an action. However, it is critizable and it has been changed by the State of Alaska.

Mr. Mahoney made reference to superfund sites, which quite frankly, I take umbrage at. Because what he's talking about is an investigation which took place in 1984 to ascertain if there were any superfund sites in the State of Alaska.

He failed to mention that there has been no followup to that report, and no indication that there are such sites in the State of Alaska, including those investigated on the North Slope.

That I must admit is an exaggeration which I find difficult to accept.

Basically, the North Slope salvaging story that he told was quite different from how he described it. The horror story was correct. It was done by a contract in a dead horse industrial area of Prudhoe Bay who was totally derelict in his duty with regard to the way he treated waste, some of which were probably hazardous.

However, having been served a violation by the State of Alaska and throwing up his hands and saying, I'm bankrupt, I'm not going to do anything about it, what happened? It wasn't DEC and EPA that went in to clean up that site. It was ARCO and Standard that did it on their own for good moral citizenship reasons.

And we cleaned it up, and we monitored afterwards until there was absolutely no material left on that site.

And so the story in reality is quite different in its hue than that given by Mr. Mahoney.

Thank you.

The **CHAIRMAN**. Thank you. Mr. Mahoney.

Mr. **MAHONEY**. Thank you. The Natural Resources Defense Council and the organization from Anchorage, Trustees for Alaska, have been conducting a survey of the records from the Environmental Protection Agency, from the State Department of Environmental Conservation, DEC, from the Army Corps of Engineers, and they testified yesterday in front of Congressman George Miller's subcommittee, and the full report will be coming out in August.

We believe that the report will provide you a very frightening picture, and a very unknown picture, of the problems of waste disposal on the entire North Slope.

And it will show you that we have not learned to mitigate and we have not learned to reclaim. And frankly, the prospects for the future are not very good.

If I understand it correctly, for a well the oil companies are supposed to put up $100,000 in bonds. But if they are doing business all over the state, they are supposed to put up half a million dollars, and that covers the whole kit and caboodle.

The problem is, as I have said earlier, in complaining to the State of Alaska about these new regulations about new stipulations, the industry is talking about costs in the millions of dollars to properly reclaim this, costs which the industry is saying are objectionable, because they are too high.

But I would also note that they are costs far in excess of what the bonding requirements are.

We go back to what the Fish & Wildlife Service said in its own internal documents that never found its way into the 1002 report, apparently because they did not please the higher ups in the Department of Interior.

The Fish & Wildlife Service said, for most of the potential impacts, mitigation measures are proposed as being able to reduce or eliminate the impact. Many of these measures have not been successful, or have been totally unacceptable to industry.

We can provide specific examples on request. Mr. Chairman, we are looking at the record at Prudhoe Bay, and I would suggest that the record is not complete; and that before you understand what the record is, should not contemplate going into this last untouched wilderness on the arctic coast, because even if we never find a drop of oil, we are going to be using toxic wastes on the arctic coastal plain in the exploration process.

The **Chairman**. Thank you, Mr. Mahoney.

The next item is concentrated caribou calving areas, and potential impacts of oil and gas development.

Mr. Mahoney.

Mr. **Mahoney**. Thank you. The proposition is, that the development of the coastal plain will have substantial negative effects on the caribou, which the Department of Interior had said could lead up to a loss of 40 percent of the population.

This has not been our favorite area to debate. We want to stress that we view this as a land issue, and a land balance issue. And one of the frustrations for us is that the industry and the Department of Interior readily conceded that the wilderness will be destroyed by the exploration process.

It is almost as if they say that the wilderness will be destroyed, but all the animals will not go extinct, so therefore, it is okay.

The industry likes to talk about the pipeline, and the environmentalists' concern about the pipeline and with Prudhoe, and as if this is going to prove that it cannot happen at the arctic coastal plain.

Most of our concerns at the time of the pipeline were that there were no studies. The famous vote on the Senate Floor, the tie vote broken by the Vice President, was a vote on whether to waive NEPA, whether to waive further environmental studies.

It was a question of whether we knew what we were doing as we went forward. Well, now, we do have studies, and we are pointing to them.

If the geologists argue about their guesstimates of what the oil reserves might be under there, when we talk about hazardous waste, we do not know what the future is at Prudhoe Bay. But we know more about caribou than any other subject that we have been trying to study.

And we know that the caribou are very precise animals. Every year, for thousands of years, the caribou come from their wintering habitat down in the central Park of the Yukon territory, or south of the Brooks range, and they go north.

And apparently, depending on the weather conditions, they calve somewhere between the Babbage River in Canada and the Canning River in Alaska.

They are very precise. They do not seem to go east or west of these two points very often, and consequently, the arctic wildlife range boundary stops at the Canning River.

It was set out there by President Eisenhower, and for a very good reason. That was sort of the way to define the extent of the ecosystem.

Likewise over on the Canadian side of the border, the Babbage River becomes the boundary for northern Yukon National Park. And what they use in between, they use differently at different years.

Now, we have been debating about core calving areas. I am not really happy about core calving areas. Because my concern is that the caribou use the whole place; not every year, not in the same concentrations in any year.

But it is not like we are coming to you and saying, the arctic wildlife refuge is not enough; the caribou are going into the state lands; we need to extend it.

No, they seem to use this place. And after calving, wherever they calve, they tend to mass, they tend to get together in incredible herd concentrations, 50,000 at a time. We have just had them on the 1002 area in the last couple of weeks, 100,000 caribou in two big groups.

Both plopped right on this 1002 area. But the scientists, all these caribou biologists, have been confronted with this question.

It is sort of like the questions you ask us. You say, well, not to take away from your wilderness position, but if you could not have wilderness, what would be the best way to develop it? Where would be the most important places to protect?

Those are the questions that were brought to the caribou biologists. And so, rather arbitrarily, they did not say, okay, forget it, there is no such place that the caribou use more than any of the others, they went back and they studied the places that they go, and they came up with places that they calve in seven out of fifteen years in particular densities, and they called them core calving areas, and they called a lot of other areas concentrated calving areas, based on the densities 50 cows and calves per square mile.

Because of that, they determined that those areas were even more important to the caribou. Finally, they looked at their studies, and despite the pictures that you see from the oil companies of caribou walking by pipes, they looked at the studies of what do caribou going to have their babies do.

And they found out—and it should not be any surprise—that pregnant caribou and young mothers, mothers of young calves, are the most sensitive to disturbance. It should not surprise anybody.

And they set upon their studies that they tend to stay a couple of miles away, one to three kilometers away, from any kind of disturbance.

All sorts of these things. And because of that, they then extrapolated what the impacts would be. And the Department of Interior, before Secretary Horn and Secretary Hodel got hold of the results, essentially just used the results of something called Report of the Caribou Impact Analysis Workshop, which was a group of 14 caribou biologists who came to these conclusions, which were adopted by the Department of Interior.

There was a general consensus. There was one dissenter, and the only dissenter was the caribou biologist employed by the oil industry.

The **Chairman**. Thank you. Mr. Herrera.

Mr. **Herrera**. Mr. Chairman, this question of core calving area of caribou is sort of an emotional one, and it is more than that, it is very crucial to the whole debate, because an obvious reaction to an understanding of a core calving area is to protect it and put it off limits to any future exploration or development.

Before people react in that fashion, they must consider the sort of experience to date, and the facts as they are known about the utilization of core calving areas, or the calving area described in the coastal plain of ANWR.

First of all what Mr. Mahoney said is absolutely right. The caribou, the porcupine caribou herd, or the pregnant females, use the area between the Babbage and Canning Rivers for their annual calving.

That is an area that is 200 miles long, and between 20 and 40 miles wide. About 8 million acres of land. It is a huge swath of acreage.

Now within that area, the debate is, are there specific regions which they routinely or preferentially choose every year for calving? And in the 1002H report, in fact, a little pink eye was established where the records were apparently interpreted to show that one particular area, core calving area, was returned to year after year by pregnant cows.

When the oil industry got hold of these records, they analyzed them in a fashion which was obviously different than that applied by some of the State biologists concerned, and came to a different conclusion.

They said, but what this map is showing is not annual utilization of this area at all. In fact, it only shows utilization five years out of fourteen, and it shows utilization by not 50 cows per square mile, as was implied in the literature, but much less than that 50 cows per square mile, and the calves do not choose where they are born.

In fact, the counts of caribou in those areas also included yearlings, so when it came down to the actual data involved, we were talking about a limited number of cows, sometimes less than 10 percent of the whole pregnant body of cows in any one year, using this area some of the time.

Now, if an argument could be suggested that when they do not use that area they are at some risk, then clearly the concentrate or the core calving area, as it is called, has value.

But nobody has ever come forward with a convincing argument of any kind which says that if the cows calve in Canada or somewhere else in this so-called core calving area, they put themselves or their calves at risk.

This is simply not an established fact or proposition.

The reality is that the utilization of the Jago River area, the so-called core calving area, is extraordinarily slight statistically.

For example in 1983, when the more detailed data start to become available, only seven percent of pregnant females use that area. In 1984, 13 percent. In 1985, we do not have the data yet, and for 1986 we do not have the data.

But it seems that in 1986 and 1987, because of circumstances of heavy snow, most of these caribou calved in Canada and not in

Alaska at all, and therefore, the utilization of the core calving area was small in those years.

So even the modern record, when we have got good hard data which everybody agrees with, dispels the myth of a core calving area. There is not one.

Now, the point is, we do not know where the oil is. Perhaps it is underneath that area. That is usually the case, you know. Oil is found in the most inconvenient places.

But if we do develop an oilfield there, what impact does that field and those facilities have on caribou, even those that use the area?

Let us look at what happened at Kuparuk, where there is the second largest oilfield in North America, right in the middle of the calving area of the central arctic caribou herd. What do we find happens? Nothing adverse.

The herd keeps on gaining population, and obviously, they keep on using the same area for calving. And obviously one has to conclude that while the oilfield is perhaps not enhancing reproductive success, it is not diminishing it. It is not having any adverse effect.

Now the one experiment which has been done to try to analyze scientifically and objectively the impact of facilities on caribou confirms that conclusion, and that is, caribou, pregnant cows, tend preferentially, as Mr. Mahoney suggested, to move two kilometers away from a man-made facility.

The particular experiment that was carried out over an eight-year period of time showed that five kilometers from that facility, the number of pregnant cows increased, not decreased.

My point is that facilities do not harass caribou. They do nothing. They are neutral to caribou.

Caribou, over a period of time, perhaps not initially but over a period of time, are going to react in neutral fashion. That is why all of the photographs of Prudhoe Bay with caribou climbing hither and yon over pads and pipeline are a true depiction of their attitude toward oilfields.

Caribou have less of an aesthetic sense than Mr. Mahoney, but it is just as well that they do.

The **Chairman**. Thank you. Mr. Mahoney.

Mr. **Mahoney**. Mr. Chairman, what is frustrating to me is that when we discuss water, we have EPA saying there has been no analysis. When we discuss, there has been no analysis.

We are just told that the industry knows how to do it, and trust them.

When we discuss toxics, we have had no studies. We have had no enforcement. We have had no monitoring, or let's just say, we have had few studies. We are told things are getting better.

Now, where is the one part of this issue that we really have studied? The scientists are quick to say, we have not studied it enough, we do not know enough. But if there is one thing we have studied, it is caribou.

We have studied their migrations and their habits over a 15-year period or so. In the porcupine herd, we have studied them in the Prudhoe Bay area. We have studied their habits. We have studied their maternal instincts.

And here, the oil industry says, do not pay attention to those studies. Do not look at those studies. Look at a picture.

I will tell you, I take a little umbrage at this idea that this is an emotional topic. I guess we get emotional about it. We think it is pretty important.

But by saying it is emotional does not mean we do not have facts. We have got tons of facts. We have got 14 biologists from the University of Victoria, from the University of Alaska, from the Fish & Wildlife Service, from the Canadian Wildlife Service, and there is a consensus by all of these scientists, except one, who is employed by ARCO.

Now, who do you believe? And is it emotional to rely on these studies which say, yes, they will be displaced. Yes, their survival rates go down. Yes, they stay away. Yes, we will have a population decrease.

Is that the emotional part of this argument? Or is the emotional part of this argument to show you a caribou near a pipeline and say, look at this picture?

I would suggest, that is the emotional argument, and not the scientific one.

The CHAIRMAN. Mr. Herrera.

Mr. HERRERA. Well, I like Mr. Mahoney's reaction. I mean, he is the one who trades in emotion usually and I trade in facts.

I thought I was utilizing facts to make my point about the core calving area, but apparently he did not understand. I rest my case, Mr. Chairman.

The CHAIRMAN. All right, the next item is, Prudhoe Bay as a model for future oil and gas activity at ANWR.

Mr. Herrera.

Mr. HERRERA. The Prudhoe Bay experience, I think, has to be looked at only in one way, and that is, as an evolving situation.

One cannot go back to 1972, when the facility was first starting to be designed and constructed, and say, that is what the oil industry is doing, has done, and will do in the arctic.

Nothing could be further from the reality. In 1972, there were no textbooks on how to build oilfields in the arctic. Nobody had ever produced one. We wrote the textbooks ourselves, and we wrote them on the basis of commonsense, and to a large extent, and we are totally willing to admit this, trial and error.

That trial and error was based on the experience of operating in the arctic for many years beforehand. But certainly not on the experience of building oilfields and pipelines.

Many of the mistakes that were made, and there were many, were recognized fairly early on and have been corrected. And if one wants to use the Prudhoe Bay experience in a rational fashion, one has to look at it in toto and see how it evolved, and see the end product of that experience.

We started off with Prudhoe Bay field itself, made the mistakes, albeit not many when you look at it in hindsight. It is really a rather good effort at protecting the environment and producing oil in a safe and reasonable fashion.

However, the errors and some of the things which were simply not understood at that time in the early 1970's were corrected when the opportunity came along to build the Kuparuk field in 1981 or 1982.

And that field demonstrably, if only because of the success of coping benignly with the porcupine caribou and the calving area in the midst of that field, was clearly a better design than Prudhoe Bay.

It gave better access to the caribou, and therefore, was more environmentally benign than Prudhoe Bay had been. It took up less space, it was more consolidated, and there were lots of features of it which were very positive.

The Milney Point field, which came along in 1984, again, capitalized on this ground fount of knowledge that was becoming available with this experience. But really the end product of all of this is Endicott.

And in fact, the future beyond Endicott, the Endicott field is a state of technology of arctic development. And if you want to ascertain what might happen in ANWR in the future, you do not look at Prudhoe Bay. Perhaps for comparison you do, but that is all.

You look at Endicott, because that is what we are doing today. That is the result of the lessons learned at Prudhoe Bay.

It is like, Mr. Chairman, trying to ascertain what a 1988 motor car, automobile, is going to be with regard to pollution control, and you have a 1987 model and a 1972 model. Which one do you look at to get some idea of next year's car?

You look at the 1987 model, and that is what we have to do on the North Slope. Look at Endicott if you want to know what is going to happen in ANWR. That gives you the clue. That is the end product of the evolution of the Prudhoe Bay experience.

Now, how do you measure that experience in nontechnological fashion? Perhaps a reasonable suggestion is that you measure it by the impact on the birds and the wildlife in the area. Irrespective of what I say about the advancing technology, if they don't like it, then it's been a failure. Certainly, environmentally it has.

Well, when we do that, as we have done, we tend to get a picture which backs up the benefits of technological advancement also. In 1987, a researched tried an in depth study of nesting birds in the Prudhoe Bay oil field, specifically aiming at ascertaining the differences of nesting densities and success and utilization of the Prudhoe Bay oil field in developed and less developed parts of it, compared with controls in a nondeveloped area of the North Slope which had similar habitat and therefore attracted similar birds.

The conclusions of that study were very enlightening. They showed, first of all, the density of nesting birds, the numbers of nesting birds, the reproductive success, and the numbers of special that were utilized in the area had not changed from predevelopment times to the present.

They had maintained their interest in the area, the birds.

Secondly, we found some surprising things that birds preferentially chose some of the busier roads. Some species did that, which nobody expected.

And some species, as commonsense would suggest, moved to the less busy roads, but still utilized the habitat within the oil field.

So that little study—or rather, that large study—came up with very positive results as far as the birds were concerned, as to our impact on the environment.

The caribou are another perhaps indicator. And the benefits, the population increases of the central caribou herd, I think speak for themselves. They live in that oil field, as the emotional photographs show, and the fact that they live there tells you something which is not emotion.

The CHAIRMAN. Mr. Mahoney.

Mr. MAHONEY. Mr. Chairman, Mr. Herrera's argument is one based on looking at a progression of events over a ten to fifteen year area, and seeing a trend and extrapolating that trend out as far as you can do it.

If I had come before here and decided to talk about energy, and saying that in the last ten years gasoline prices have gone down, gasoline lines have gone away, we have changed our Federal laws to deemphasize conservation.

We have ended the Clinch Fuel breeder, the Synfuels Corporation. We are less reliant on Middle Eastern oil. We have made progress on the strategic petroleum reserve, and we have wells shut down all over the country that could come on and make more productive use of oil as soon as the prices do it, everything I say would be true.

But if I tried to extrapolate from that argument and say, we do not have to worry about finding new energy sources because prices are not going to go back up, we are not going to have problems with sources, you would not believe me, and it would not be true.

You cannot take this as a linear progression. If we could rely on the energy trends, the debate over the arctic would pale compared to the debate we had on it in 1977, 1978, 1979 and 1980, when we were in an energy crisis.

So I am not going to accept what Mr. Herrera has said about the quality of life at Prudhoe Bay. I think the discussion of toxics itself is enough to give anybody pause to worry about the environmental performance of the industry there, and the statements from the EPA, the statements from the Fish & Wildlife Service about their problems with EPA, with the industry, on reclamation and mitigation, I do not think the record is very clear at all.

But if you look at this whole premise of the 19 percent chance of finding oil in the arctic refuge, that whole 19 percent premise is based on a premise of $33 a barrel oil; that is, the price going up.

We are not saying that is not going to happen. But we are saying, if those prices go up, and we are sure they will, then let us look at Prudhoe Bay then, because we will not just be talking about a couple of fields.

We will be talking about a great many more fields that have been discovered and delineated but have not been developed. And they have not been developed because the prices are low.

But when the prices go up, whether Congress does anything with the arctic refuge or not, we are going to have more oil, and we are going to have growth of Prudhoe Bay; we are going to have a spreading of this industrial development.

And if the industry strikes it rich offshore and it is making the investments to try to, then, we are going to have maritime pollution.

We are going to have those additional complexities of this development. And if Canada does well with the MacKenzie Delta and offshore, we are going to have more industrialization.

Now, maybe there are going to be improvements in the industrialization, and maybe there are not, but there is no good way to develop a wilderness area. And the wilderness area is what is at stake here.

Now we have played out our story, our analogy of the Grand Canyon, and the choice that Congress had there of energy versus preservation; the black and white choice.

And we have talked about how the Grand Canyon, while left undammed, the Colorado River has been dammed upstream and downstream.

Now our question is, the fact that we have dammed all the rest of the Colorado River, the fact that all the rest of the Colorado River has been put to work, does this make the protection of the Grand Canyon more important or less important?

Because the success of those dams, the work that they do, does that make it more important to protect that park, or less important?

We submit that if you learn more about Prudhoe Bay, you are going to find more questions and answers, and that far from this getting to be an ever shrinking pool of environmental concern, it is going to become an ever spreading concern.

And as the pipeline and the whole road perhaps have public access, as businesses creep up, this place could become an industrial area. It is an industrial area, but it could become a big one.

We would say that is not the experience that should be put on our last wilderness on this coast. And we would say that that makes that wilderness even more valuable to our children than it is today.

The CHAIRMAN. Mr. Herrera.

Mr. HERRERA. I had a hard time finding anything to sort of rebut in Mr. Mahoney's remarks there, Mr. Chairman.

Perhaps for his edification I might just discuss this $33 oil that he brought up. Irrespective of what is in the 1002 report, whether an oil field is economic in ANWR is not a function of whether the price of oil goes up to $33.

It is much more a function of the geology of the oil field itself that happens to have been discovered. Now if that oil field contains 6 billion barrels of oil in a huge thick oil column, in a beautiful sandstone, which is just waiting to push it out to the surface, your operating costs of developing that oil field are going to be down to the place of a few dollars a barrel, and probably that would be an economic situation even at present prices.

So there is nothing required or magical about $33. It is just a price that has been pulled out of the air on the basis of the type of oil fields which have been found at Prudhoe Bay, excluding Prudhoe Bay itself.

The problem I have with Mr. Mahoney's wilderness arguments is a twofold problem.

One, I can understand and perhaps appreciate them almost as much as he can.

But, two, I find this exaggeration, I mean, the arctic coastal plain of ANWR is not an untouched, unsullied wilderness by any stretch of the imagination.

We have got DEW line stations along the coast, one of which is still operational, which heaven forbid, I hope stay there. We have a native village there, obviously the inhabitants of which subsist in the area, which I have no objection to.

We have had native utilization of the area for reindeer herding for tens of years in the early part of this century up to the late 1930s.

Now, surely agriculture is not part and parcel of wilderness.

And then we look again, the problem I have with this argument is apparent to me when I look at the national petroleum reserve in Alaska, at the other side of the North Slope, a huge area which has had 128 exploratory wells drilled in it by industry and the government.

Perhaps the government is even worse than industry. I do not know. And yet that area when you go into it today is an untouched wilderness, and I would recognize it as such, and I think Mr. Mahoney would when he goes to see it.

There is nothing bad or nasty or scarred by man in that area. It has reverted back to what it was before anyone went in.

So I perceive there are benefits from producing oil in a responsible rational fashion, with decisions made on the basis of information, rather than rhetoric and emotion.

That is what the system is set up now. That is what Endicott represents, and that is what future oil development will represent.

You do not have to give up your wildlife. You do not even have to give up your aesthetics of wilderness. You only have to go a few miles away from an oil field, and you are still in the wilderness in the arctic.

And if you go up there in the winter time, even if you are in the middle of the oil field, Mr. Chairman, you are in the middle of a wilderness.

The **CHAIRMAN**. Mr. Mahoney.

Mr. **MAHONEY**. Thank you, Mr. Chairman.

The Department of Interior report did not say this was any wilderness. It said it was the only ecosystem that had all of the components of arctic ecosystems on the continent in one place.

And it said that the 1002 area was the most biologically productive part of that ecosystem, and the center of the wildlife activity.

It is not just another piece of land.

The problem with the NPRA argument is that what we have here is a public treasure and a public trust. And we would be turning it over if we lease it to private companies, and their private decisions about whether to develop it or not.

And that will depend on what they find and how much it costs. So if there is something left, it will have more to do with what the oil companies decided to do, and what was left, than any conscious decision that we made about what it should look like.

I am most flabbergasted by what Mr. Herrera said, that price is not a very big factor in determining whether the 1002 area is a place to go into. If that is the case, then I would hope you would ask the Department of Interior to recalculate what it thinks are the odds on finding economically recoverable oil at our present prices, because I think you would see that they are below the 19 percent level. They are much smaller.

Now, while it does not matter to us whether they think there is a 100 percent chance there, like in the Grand Canyon analogy, or a 19 percent chance, they have been going around talking about the 19 percent chance, and then 95 percent of this, and 5 percent of that.

And I think you ought to ask for their calculations, based on lower prices. I do think price is important. Otherwise, fields that are in the state lands of the North Slope adjacent to Prudhoe would be operating today, but they are not because the cost is not right.

The industry would be foolish not to wait for the price to go up. Indeed, if you take away the spectacular environmental issue involved, the spectacular wilderness, there are a lot of similarities between this issue and the same propositions that have been brought by this administration, a sort of sell low buy high proposition with energy development.

And that is the Powder River coal sale or wide area offshore leasing, the lottery system, for oil and gas operations on shore.

I have no doubt why the industry wants to develop the Arctic coastal plain now. One reason is they have a lot of political help in the administration, and another reason is, prices are low.

But the development of that oil, if there is any, would be left to the industry.

And I cannot believe that the industry will not pay some attention to what the world oil price is.

The CHAIRMAN. Thank you.

Our final issue is air quality, and Mr. Mahoney will lead off.

Mr. MAHONEY. Okay, Mr. Chairman, this may be pretty anticlimactic after the fireworks we have had, because if I said that the caribou was the piece of the puzzle we know most about, the air is probably the piece of the puzzle we know the least about.

We believe it is a serious problem. But it is pretty hard to find out any facts about it.

Certainly, as you will see, on the North Slope, we are talking about a giant industrial facility, and a giant industrial facility pollutes.

Some pollute worse than others, but there is pollution. The air pollutant that we have talked about the most is nitrogen oxides, and this is where you have heard about the emissions rate being one-third of the five boroughs of New York City, or equivalent to the entire State of Maine.

I am always amazed that unlike Maine or New York City, which has a fairly large population and a lot of automobiles, in Prudhoe Bay it is all coming from industry, because there is a very small population, and no private automobiles.

Nitrogen oxides are considered by the scientists to be one of the principal causes—not the only one, but one of the principal causes—of acid rain. We have a desert up here, so we call it acid deposition, and we talk about rain, snow, fog, ice fog, maybe even dew.

We, EPA, has expressed concern about the increasing acidification of the tundra from these depositions. But they have never been studied.

In fact, most years, we have not had any monitoring, unlike the issue of the caribou which we study every year. We have only studied the emissions two years, if I understand this correctly.

We also have a phenomenon called arctic haze, which Prudhoe Bay may or may not contribute to. I cannot imagine that you can put a giant industrial facility in the arctic, and not have it contribute to this very small slice of the earth.

But we certainly would concede that a large amount of arctic haze probably comes from the increased industrialization of the arctic and subarctic portions of Europe and the Soviet Union.

A problem is that there is a big stew up there.

Now, the other thing which we note, and has not been studied, are things called black smoke incidents. Black smoke, which I am not sure what is in black smoke—I am not sure anyone is really sure of it—appears to be made up of hydrocarbons, and may contain some toxics.

It is what comes out of a flare when a new facility is brought on line. And there are a number of black smoke incidents which have been seen by casual observers or visitors to the Prudhoe Bay site.

These huge plumes of black smoke may go 50 or 100 miles, or certainly be seen 50 to 100 miles away. Which indicates that if you were standing on the shore line of the arctic wildlife refuge coastal plain during one of these incidents, you would see it.

And we are not sure where they go.

The State of Alaska has guidelines that say that the black smoke should go for no more than three minutes out of every hour unless there is an emergency, unless there is a problem that some damage to the equipment or personnel could result from keeping this aura, of not flaring this stuff up.

But the industry does not seem to treat it that way. In the one year that we have a complete compilation of reported incidents, in 1985, we had 150 of these incidents. And one time, between 1986 and 1987, while I think it was the Lisburne field was coming on line, we had black smoke incidents over a 37-day period.

So the State of Alaska compiles these things. The oil industry makes a note that they have had a black smoke incident, and calls in the State.

The State puts it on a computer and says how much black smoke they thought was out, and how long the incident went. And we asked an intern, I guess, of Trustees for Alaska, to add up all these minutes here in 1985, and we came up with 360 hours of black smoke.

And this is a printout of what that looks like. I wish we could say more, but of all the things that have been studied, air pollution is not one of them.

The CHAIRMAN. Mr. Herrera.

Mr. HERRERA. Mr. Chairman, the baseline data for air pollution discussions at Prudhoe Bay was gathered in 1979, 1980, over a 12-month detailed measurement program.

Subsequent to that time, every new item of equipment which has potential emissions from it has been tested by law. And so those facts, those actual measurements, together with modeling, which is a normal technique for predicting the incidents of emission in a given area, have been used to track what was happening the Prudhoe Bay region, from 1980 until 1986.

In fact, in 1986, it was decided that there was sufficient cumulative addition of horsepower, mostly turbines and heaters, which gave off mainly NOx to the atmosphere, that the spot stack testing needed to be verified with a region-wide testing.

It is not correct, though, to suggest that testing was not happening in the period from 1980 to 1986. It was ongoing perpetually. In 1986, a region-wide and yearlong test was initiated, and it is still ongoing, and it will come to an end in the next few months.

The results of all this work are on the record. What has consistently been done with those results is, for reasons I do not understand unless you have a negative turn of mind, is, to exploit them irrationally.

And the method that is used is as follows. Whenever a new piece of equipment is permitted to operate on the North Slope of Alaska, a calculation is made as to the amount of pollutants that that machinery will put into the atmosphere.

That calculation, which follows very strict guidelines set up by EPA and DEC results in a permitted emission for the particular turbine, or whatever it is, of X tons per year. This is a permitted amount which is a theoretical figure. It is calculated on the basis of a full exploitation of the machinery at about 110 percent efficiency in worst atmospheric conditions, giving to a worst case of pollution by that machinery.

And we get these permitted levels, which you can add up for all the pieces of machinery on the North Slope, and on an annual basis, it has been calculated that those permitted levels of pollution add to about 74,000 tons per year for the whole of the Prudhoe Bay region, 74 to 80; you know, the addition is a little ropey occasionally.

This figure is used, then, to compare the actual emissions of NOx in New York City, to make the suggestions that Mr. Mahoney is so in love with, that Prudhoe Bay gives off one-third of New York, or as much as the State of Maine, and things like this.

The reality of the situation is the actual amount of emissions of NOx which Prudhoe Bay puts in the atmosphere is less than 20,000 tons a year. That is the measured amount that is put into the atmosphere.

And if you are going to compare apples and apples, you find that Prudhoe Bay in fact has a better record than any other major city in this country.

Now, that is almost academic because the amount of pollutants you put in the air obviously is good for argument, but it does not really measure the effect on people, and surely, that is primarily our concern.

It is when you measure the ambient air quality that you are actually measuring the health, the effect on the health of human beings. And by ambient air quality standards, Prudhoe Bay has a record to be proud of.

It far exceeds all the cities that we are familiar with, the large cities, and in fact, is at a level of about 50 on a scale which is generally recognized as 100 to being a level which is safe for human breathing in worst case humans with asthma and things like that.

The CHAIRMAN. What is Washington, D.C. today?

Mr. HERRERA. Pardon?

The CHAIRMAN. What is Washington, D.C.?

Mr. HERRERA. Probably about 75 on that same scale, as against 15 for Prudhoe Bay.

Senator MURKOWSKI. Fifteen?

Mr. HERRERA. Yes. This is the true measure we should be worried about, if we want to argue the statistics of the air quality of Prudhoe Bay. That is what we should be arguing.

Let me in the last minute talk about black smoke. Black smoke is there. We report it, and the records are there, which Mr. Mahoney has collected.

The point about it is, first of all, a couple of facts. Black smoke represents the flowing of gas, natural gas, which for some reason cannot be treated in the normal way in a system where it does not flow to the atmosphere at all.

It is an emergency situation when black smoke occurs. A piece of equipment is shut down, or broken down quickly, and you have got to move vast quantities of gas out of your system; otherwise, you have got an explosive situation, so you flare it in the atmosphere.

You have got it permanently burning. A pilot light flares for that reason. The actual combustion of the gas if about 95 to 98 percent in those flares.

The two to three percent which you see as black smoke is carbon, and carbon is not a particulate which is damaging to health, as far as EPA standards are concerned.

Mr. Chairman, I could go into much more detail on black smoke, and why in fact it still happens in Prudhoe Bay. There are good, rational explanations for it, but I have run out of time.

The CHAIRMAN. In our final surrebuttal, why do not each of you just sum up, if you would like to, in addition to surrebuttal, do not feel limited to the issue of air quality.

Mr. Mahoney?

Mr. MAHONEY. Well, Mr. Chairman, I am not the most well qualified person to talk about air pollution, being the person who works around this committee on land issues.

But I am told in the NRDC trustee study that the self reporting of industry indicates levels of NO2 and SO2, these precursors of acid rain, are increasing, and that the levels reported in 1986 are much greater than the levels that were reported in 1980.

Furthermore, there is something in the Clean Air Act called the prevention of significant deterioration, PSD program, which is what we talk about when we are talking about pristine areas, as opposed to cities.

For reasons that elude us, EPA never established the guidelines for PSD requirements for nitrogen oxides that they were required to under the Clean Air Act.

In fact, my organization, Sierra Club, finally got them to do this, or got them to start doing this, under court order. So we have no guidelines for NOx when it comes to the prevention of significant deterioration.

Now, when we talked at the last hearing, you asked a number of questions, which I have gone to try to learn a little bit about, about what makes this place so special, as, is there something about the atmosphere here in the arctic that makes a ton of pollution worse here than a ton of pollution in Louisiana or something like that.

I am not sure I can answer that really knowledgeably. But I can tell you that biologists believe that the plants that live in this most extreme environment, the plants that are adapted to these polar regions, after all, they are virtually on the end of known plant life as we know it, are more susceptible to changes in their habitat, more susceptible to acid, than are plants here in the temperate zone.

And we know from the forest industry that there is great concern of things like acid rain and acid depositions on forest productivity.

We have those same concerns about the tundra, and we are not just talking about plants, and they are not cute like caribou. They are the food for the caribou and the lemmings and everything else that this ecosystem is built on.

About all we know for scientific study so far is that one kind of caribou herd, something called a fruticose lichen, which I thought was a breakfast cereal when I first heard it, reindeer moss I guess it is, does show signs of being severely damaged in its productivity due to air pollution.

What happens to the rest of the sedges and the grasses we do not know. We think we should know. We have instances in our west where there are national parks, and the Park Service is coming to us, and obviously, the national parks are not polluting, and they are talking about damage to these parks from industrial pollution nearby, damage that we never conceived of a few years ago, and damage that we never conceived of when we were putting down some of the initial requirements under the Clean Air Act.

But they are damaging the parks. They are damaging the vegetation. They are damaging the petroglyphs or whatever. And we suspect that that is happening here, and that the pristine air over the arctic refuge, which is going to be the most pristine place left, is the most valuable place, not the least valuable place.

And as Prudhoe grows, air pollution will grow, too. We just think you should study it.

The CHAIRMAN. Mr. Herrera.

Mr. HERRERA. Just a few details, Mr. Chairman. Mr. Mahoney seems to want acid rain to be found up there, and there is absolutely no evidence of acid rain the arctic.

In fact, if you are logically going to look for it, you would look for the formation of nitrates, because the pollution, we have readily identified and been talking about, is principally NOx gases.

So you would have nitrates falling out on the ground when in fact nitrate concentrations on the North Slope of Alaska are measured. They are about the same level as the Antarctic.

There is no evidence yet of a level, and he wants it apparently showing the formation of acid rain from the nitrate pollution, or NOx pollution at Prudhoe Bay.

Now, perhaps it might happen. I cannot say for certain that it does not. We do know that nitrogen oxides do contribute to the formation of acids, but there is simply no suggestion that is happening at the present time.

And it is incorrect to say that people are not concerned, and are not measuring for that, because in fact we are.

The other point I want to bring up, which is a detail I would rather have left out, but he mentioned it when he suggested in this trustee's testimony of yesterday that it indicated that the NOx and SO2 levels have increased between three and tenfold since 1980 in Prudhoe Bay.

You know, you can do all sorts of things with figures. Unless you are sort of scientifically reasonable with them, you can skew them in any fashion you would like.

What was done to arrive at these figures, and fortunately, they give the source of where they get them from so I was able to check it, they compared as usual apples with oranges.

They went to a measurement of NOx at Prudhoe Bay in 1980 which was close to a pollutant source, deliberately placed so to get a maximum worst case measurement. And then they went to—I am sorry, the other way around. That was a low sort of regional measurement, which got a background measurement if you like, the original measurement.

And then in 1986 they went for a figure for Kuparuk, not Prudhoe Bay at all, and took the close-to source, worst case figure, and compare the two, and found one three times bigger than the other.

Big deal. Perhaps that would suggest that, but it was not a comparison of apples with apples, and therefore, it should not be quoted as rational evidence that shows something is worse.

The rational evidence suggests that the air quality is in pretty good shape, and it is certainly not getting worse.

It is sort of this skewing of data which is disturbing in this debate. If we could all talk about the same things and agree that we are using the same data, and come to conclusions on the basis of that, I think we would be better off than we are at the present time, grappling with things which are skewed and distorted, and sometimes, rather outrageous.

The CHAIRMAN. Thank you both. Why do we not now go to questions. And I would suggest that we hold ourselves to about ten minutes.

Mr. Mahoney, wilderness is a very big value for all of us. And I am sure especially for Members of this committee.

But it means different things in different areas. And it means different things to different Members of the committee. We get poetic about it. We talk about it as treasures and values and that sort of thing.

There are at least four different values that I can think of for wilderness. There is a value for men to get in an area of solitude. We know that well.

There is a value for wildlife, both for wildlife to exist in the area, and to propagate outside the area.

There is the effect on other ecosystems even though man might not go to the ecosystem, it might have an effect on others.

And fourth, there is this intangible value of just sort of knowing it is there, whether anyone goes there, whether it has any effect on it. Just the idea that it is there, and great and unspoiled, is a valuable thing.

What I want to ask you, and also, I would like Mr. Herrera to respond, is, if those are not all four, give whatever other values they are, and what are the relative values of them?

Is there enough potential for man's presence to really be important? Is there a big effect on wildlife, et cetera? Would you explain what you see as the values?

Mr. MAHONEY. I'll try. If you read the 1964 Wilderness Act, as I know you have, you will find it is rather poetic in its reading. It is a very unusual piece of legislation, talking about a place where man is a visitor who shall not remain.

The items that you have described could describe any wilderness, and we have spectacular wildernesses, wildernesses ranging from tiny islands in the Gulf of Mexico, or in rivers in Pennsylvania, up to some of the big ones like the Bob Marshall, and the river of no return, or the de factor wilderness of our great parks, Yellowstone, Glacier, Grand Canyon.

In each of these instances, we have tried our best with what is left of this country to stake out an area and say, no, let us just leave this as God meant it, for all of the reasons that you suggest, including this kind of hazy idea that it exists, and for science as well.

Because these are the only places that are our control plots for experimentation. They are the only places where the ecosystems are playing as they should, we assume.

The problem we have in the lower 48 states is that we probably do not have a complete ecosystem, not one.

You have legislation on Big Cypress and the Everglades National Park. We are trying to put together additions and land swaps because we found we did not protect the whole watershed, and those are dying.

Some years we have floods. Some years we have fires. We have debated oil and gas leasing around Yellowstone National Park, and geothermal leasing around Yellowstone Park, because we have a ecosystem that is kind of spilling out the edges, with grizzly bears, with whether to put wolves in it or not.

It is as phenomenal as we can have it, but it is not complete.

In Alaska, we have complete ecosystems, or as close to complete as we can find on our continent. So when we talk about beautiful scenery, or we talk about wonderful animals, we are really talking about something that the wilderness provides for, that the land provides for.

And it has taken all your values in total. You cannot improve this habitat by adding a lake. You cannot improve this habitat by some mitigation or game management.

It is as good as it is going to get. And what is amazing about this particular area is, as you will see, because it is a relatively narrow little spot, we have the various sub-ecosystems of the Brooks Range and Boreal Forest kind of overlooking this coastal plain where the caribou are coming up and going out.

And then we have a maritime environment, including things like the polar bears wandering up and getting on shore.

So we have all of these ecosystems coming into place in one place. So when we dismiss the wilderness and say we can manage the caribou, it is sort of missing the point.

The wilderness is the wellspring from which all of these values come. And to say, yes, the wilderness is gone, it is too bad, is to understate it completely.

I tried not to do this too many times. But Senator Stevens, in debating whether to locate a gas pipeline across this area, who compared it to slashing the face of the Mona Lisa with a razor blade.

In using this analogy, the smile of the Mona Lisa takes a very small part of the area of the entire picture. But it is a pretty important area. It makes the whole picture work.

Likewise this little piece of the wilderness makes the rest of the wilderness work. And since the United States has put most of the rest of this habitat, this ecosystem, in protected status, and Canada is doing it, it is the last place we have this opportunity.

The CHAIRMAN. Mr. Herrera, at the risk of slashing the Mona Lisa's smile, would you like to respond?

Mr. HERRERA. Well, basically, Mr. Chairman, my perception is sort of skewed, because of the fact that I have walked all over this area when I was young and fit, and I know with a degree of certainty that I have the capability of freezing to death on the North Slope of Alaska within sight of Prudhoe Bay, or 40 miles away, and Prudhoe Bay simply does not exist as far as my environment is concerned at that time.

It is a vicious, hard place for most of the year. Of course, the visitors see it at its best, and when it is at its most serene. But most of the time, it is not like that at all.

My point is that Prudhoe Bay is a little tiny dot in that huge, great wilderness. And if you are up there even during the middle of summer, and you are 20 miles south of Prudhoe Bay on that tundra, you are in the middle of nowhere, and you have got nowhere to go, either without getting eaten to death by mosquitoes and put to great physical inconvenience, to say the very least.

Now, if you are in an airplane, that is different, is it not? But really, can you appreciate sort of Mr. Mahoney's wilderness from an airplane? I would assume not.

The reality though is that you can have your cake and eat it too, in my view. You can develop in a rational, reasonable way to get the oil, which obviously is a valuable commodity. If it is not, then there is no debate.

If it is a valuable commodity, you can do that reasonably, and you are not going to forever destroy that wilderness. I mean, only in textbooks do you do that when you are not physically there.

When you are physically there, the whole ecosystem keeps on going despite the presence of a small oil field occupying less than one percent of the coastal plain.

The CHAIRMAN. Mr. Mahoney, suppose we had it to do over again with respect to Prudhoe Bay, and we knew that our vote in this committee, let us say we were going to vote today whether to redo Prudhoe Bay, that we would replicate that with all its faults and all its oil?

In other words, there would be a 100 percent chance of finding exactly the amount of oil and the pipeline would cost the same amount, be put in the same place, and everything would be repeated, waste pits, the whole thing.

Would it be worth it? Should this committee approve or not approve of Prudhoe Bay if we were redoing it today?

Mr. **Mahoney**. That is a pretty tough one. Bob Marshall, the great wilderness leader, and Forest Service employee, founder of the wilderness system in the agency, once suggested in the 1930s that we make everything north of the Yukon River a Federal wilderness, because in the 1930s, it looked like we could.

As we changed, and as the committee and the Congress looked at this issue, we did not have many conservation units established. We did not have the Arctic refuge established.

I guess I cannot say that we should not look for energy, and I would not say that we should not use Prudhoe Bay oil. I wish we could do it better. I wish we could do it more carefully.

I wish we could do some experiments before we turn it over to private industry. I wish there were some way in our leasing system we could say, stop, you are doing it wrong, instead of just leaving it really to the industry, but I cannot do that.

But I do think that while we need to find oil, we do not need to use oil every place it may exist. There are some places, there are values that are more important than oil, and there are some places where values are more important than timber.

We have parks in our cities. We have a mall here in Washington, D.C., that would be worth a lot to the real estate industry if we turned it over.

We would be talking of lands more valuable than Prudhoe Bay, I guess. But we have decided it is important to us as a people to have this space, this beauty.

Now, we would say then that that should not be developed. And likewise, there are places we hope, in each of the world's great biomes, that we leave some place alone.

And maybe we do not have the opportunity in the biome to know whether there is really oil there is not. We suggest you are better off not looking.

You can do a lot of things while not looking in the Arctic. You can see how they do in the Beaufort Sea. You can see how the state leases. You can see whether Mr. Herrera's promises of future improvement at Prudhoe Bay come true.

You can do all of those things, and still decide later if you wish that we were wrong, that wilderness was not so important.

But you cannot develop the wilderness and then go back and say, we made a mistake. Let us fix it.

So we think there are some places, even if Prudhoe Bay exists, and even if it should exist, there are some places where it does not need to be extended, and should not be extended.

The **Chairman**. Mr. Herrera.

Mr. **Herrera**. Mr. Chairman, being a sort of explorer after oil, I have an obvious answer to your question, simply because I find oil desperately difficult to discover.

It does not give itself up, and it is a commodity that we place a high value on, and it has a high degree of utility.

So, yes, you would have to make the decision to go after a deposit of oil that large and that significant to the Nation, irrespective of the environmental cost involved, assuming that is, and I think this was your premise, the environmental costs would be the same as we have experienced today.

The CHAIRMAN. I have more questions that I could ask, but will yield to Senator Murkowski.

STATEMENT OF HON. FRANK H. MURKOWSKI, A U.S. SENATOR FROM THE STATE OF ALASKA

Senator MURKOWSKI. Thank you very much, Mr. Chairman. I think your foresight in inviting our distinguished contestants, I guess might be a word, to what amounts to the great ANWR debate has provided somewhat of an aftermath of the Iran-contra hearings inasmuch as you have been able to keep a full house, Mr. Chairman, virtually all afternoon.

I find some degree of frustration, recognizing that it is not my role to involve myself in the debate, so I will attempt to restrain myself.

Hopefully, I will be mildly successful. My remarks are going to be in the appropriate format, and that is, of questions.

However, I think it is customary that a short opening statement might be allowed, and with that, not necessarily negative or positive response, I would say to you that the format, while being unusual, I think has been constructive, because seldom do we get an opportunity to see both sides of the issue.

And when we hear statements made that gravel is a problem, and the response is that gravel is not a problem, that water is difficult to find, there is not very much, and that water can be found, and there are techniques that are available, why, one is still left with the question and/or questions as to whether it is practical, whether it can be done in an environmentally compatible manner, and that is as it should be.

I guess I have a natural sensitivity which I cannot help but express in view of the fact that I have lived in Alaska since I was six or seven years old, and I spend a good deal of time in all areas of Alaska, including the North Slope.

And I find some of the testimony of a general nature, and generalizations being given, which I find somewhat offensive, but I can understand, although I think the record should note that we have two individuals who have been kind enough and willing to [illegible] themselves in some regard to this committee.

But I think it is fair to say that their testimony will be regarded somewhat along the lines of expert witnesses. And I think it is appropriate that we have for the record résumés based on the background of both of our contestants here today, because I think it is relevent to the subject matter.

And you know, my sensitivity to Mr. Mahoney's testimony is colored a little bit by the fact that he represents the Alaska Coalition, which implies a certain association within our state, and correctly so.

But the realization that he has not visited Prudhoe Bay, that he has not been in the 1002 area, so his testimony realistically comes from information gathered by his colleagues, pictures, expertise, periodicals, and that is understandable.

But if I were to come to Washington, D.C., Mr. Chairman, as a party in the debate on the humidity, having 44 years in Alaska, I guess my credibility would be somewhat questioned at least as to my degree of expertise as one who has spent a great deal of time in the study of humidity.

But I will not bear that any further.

One of the things that I would like to clarify is the issue that has been brought up from time to time on the ecosystem, and the uniqueness of it.

Mr. Mahoney, it is my understanding that there is approximately 18,900,000 acres in the Arctic National Wildlife Refuge.

In your testimony, you referred to wilderness. I counted four or five times, then I lost count. But in fact, the designated wilderness is 8 million acres or thereabouts, and what we are talking about is a 1002 area, which is not a wilderness.

It is approximately 1,550,000 acres, and there is an additional roughly 9 million acres that is a refuge.

So I think in all fairness to the issue of wilderness, and the issue of the ecosystem and its completeness, you have to keep it in perspective.

You know, I would ask you in view of the fact, as has been pointed out in the testimony, within the area there is the DEW line sites, there is Kaktovik, there are other areas, and I do not dispute your contention that you can never have necessarily too much.

But is there not a reasonable point where you reflect on the merits of what is an ideal ecosystem. I mean, we could go on and on and on. We could have included Prudhoe Bay. We could have included Naval Petroleum Reserve No. 4 as being ideal.

Or as you stated, everything north of the Yukon.

So what we are doing here is, we are operating in matters of degree. You did not answer the Chairman's question directly with regard to Prudhoe Bay, and I can understand that. But the Congress basically came within one vote. The Vice President broke the tie.

Where would the Nation be today without Prudhoe Bay? Twenty percent of our crude oil is dependent upon that. Why, we would be in a different set of circumstances.

We would obviously survive. We would be importing more foreign oil from Mexico or Canada or other sources. So what we have here is a balance.

I think as you referred to wilderness in your general testimony, it has to be kept in the perspective of the 1002 area, which is what we are talking about.

Mr. Chairman, I could talk about the reflection on the reality that history repeats itself. And I think we can reflect that many of the issues that we are talking about today were intensely debated 15 to 20 years ago, by very concerned people like yourselves, and industry people who were responding by indicating that they felt they could do the job in a reasonably compatible manner.

And the question of whether to build the Alaska pipeline was certainly one of those. Congress heard predictions of horrible environmental disasters that would result from the development of

Prudhoe Bay. A total wipeout of the caribou herd, the moose population. They would not cross the pipeline. They would not cross the highway.

What they predicted would result from the development of Prudhoe Bay, and the construction of the trans-Alaska pipeline system. But the reality is, these predictions did not come true.

And you know, I would hope that we would recognize that we could learn something from history, and recognize that from the history we have had, there is a reasonable comparison. There is technology available that is being put to use, and is representative.

You know, the caribou did not perish. They have flourished. Reality dictates that one recognize the fact that the central Prudhoe Bay herd today at 14,000 animals is in comparison with about 3,500 to 4,000 animals in 1972.

These are facts. Now, these caribou have been brought up around development. And they apparently have survived quite well.

Whether you can extrapolate that over to the porcupine herd, you have got differences of opinion. But certainly, we have a simile there, a realistic one in a sense, of comparison, and just to disregard it I think is a little unrealistic.

Certainly the environment of the North Slope has not been destroyed as predicted. And you know, as we examine the merits of oil and gas leasing on the coastal plain of ANWR today, we are hearing the same predictions of disaster today from the same environmental organizations.

The only difference is the players have changed. This time around, the organizations are pointing in some instances to distort the established record at Prudhoe Bay to serve their purposes.

Now, before we did not have a record. There was not anything to distort. We have a record. And I find it incredible that you would not have a very personal knowledge of an area that you are espousing to this committee as testimony that can be taken as that of an expert witness.

I would truly urge you, and I respectfully request, that you get up there as soon as you can. Look at it for yourself, and look at it objectively.

You are not going to agree with the position of Mr. Herrera or the industry or anybody else. But in fairness to all concerned, I think it is mandatory.

And I am so pleased, Mr. Chairman, that you are leading an energy trip.

The CHAIRMAN. If the gentleman will yield, we have invited both Mr. Mahoney and Mr. Herrera to accompany us on the ANWR part of our trip to Alaska. So they will presumably both be there; I hope they will. And along with fish and wildlife people from Alaska, as well as people from the State of Alaska.

So we will have good experts there. And both will be there; I hope both will come.

Senator MURKOWSKI. I certainly hope that both are able to come as well.

You know, as we look to the merits of the mandate on our budget reconciliation, Mr. Chairman, what are we talking about? Six to seven hundred million dollars savings out of this committee in the next three years, something like that.

And you know, the questions of whether ANWR should play an appropriate role in our thought process is a legitimate consideration before this committee.

My time is up. And I have not asked a question, so I will defer to my turn on the next time around.

The CHAIRMAN. I think the answer to your question from Mr. Mahoney is no, from Mr. Herrera is yes.

Senator MURKOWSKI. I think you are correct, Mr. Chairman. That is what I anticipated all along. [Laughter.]

Mr. MAHONEY. Senator Murkowski, I acknowledge the shortcomings. I think they mean that I am not as effective a witness as I could be, I hope. And I hope to learn a lot when we go up there. I hope afterwards maybe we can do this again.

Senator MURKOWSKI. I would hope that I could get on one side or the other.

The CHAIRMAN. Well, I will say this, Mr. Mahoney, your testimony, at least in my eyes, has not suffered by lack of preparation, I can tell you that.

Mr. MAHONEY. Thank you.

The CHAIRMAN. I think you have done very well indeed. I see that our colleague from Georgia has not left.

Senator FOWLER. Yes, I am still here.

I also want to say, not to criticize my friend from Alaska, that it would not be a bad rule to have people knowledgeable and having seen things that they talk about before the United States Congress. But if we had that rule, we would eliminate about 85 percent of the witnesses.

The CHAIRMAN. And about 95 percent of the Senators. [Laughter.]

Senator FOWLER. In fact, the confluence of those two makes for very good public policy. [Laughter.]

Let me, for what it is worth, I have been to Prudhoe Bay in the days of my misspent youth. And I look forward to going again with the Chairman. But let me ask a couple of questions.

Oh, and I do want to say, to echo the Chairman, we say this but in this case we mean it, I do think that both of the presentations were excellent, and will be extraordinarily helpful in the final decision.

Certainly speaking only personally, in helping me to make up my mind, which in truth has not been made up.

Mr. Herrera, let me ask you a couple of things. First, at what price of oil will the oil companies begin to develop shale?

Mr. HERRERA. Wow.

Senator FOWLER. Let me, so that I am just not playing Iran-contra here, I could lead you down a path and then zap you. I will not do that.

Let me say this. This is my 10th or 11th year in the Congress. On the Ways and Means Committee in the House, in the debate over the windfall profits tax, we were told that at about $20 a barrel, and this is oil company testimony, they would be developing all the shale.

Then they hit $20, and they said no, it is going to take $30 a barrel. And then it hit $30, and they said, no, it is going to take $40 a barrel.

And then it got to $40, and we out of politeness stopped asking.

So even with that forewarning, why are you not developing oil out of shale, and when will that happen?

Mr. **Herrera**. Well, I am not the right person to answer your question, Senator, but I will certainly give it a shot.

One can suggest that there is a finite price to oil, at what level it is I do not know, perhaps $50, $60 a barrel, and thereafter, alternative sources of energy become economically viable and start displacing oil.

So one can never contemplate the price of oil going up above that level.

Now this is just sort of logic, if you will, rather than experience. Now whether oil shales come in before that price or after it, I do not know. I mean, the experience suggests you can go up to $40 a barrel, and you will still not be economically convinced that your oil shale operations are profitable.

That is what has happened in the past. I do not know personally of any technological breakthroughs to change that situation. So it is up close to the economic limit of a viable price for oil.

Senator **Fowler**. Let me ask you this, just for the record, and so that we are debating off the same figures.

Do you agree with the figures that have been bandied about mainly by—or presented, I ought to say, presented mainly by Mr. Mahoney, that in any given situation, even where all the geological indicators show that there is a high probability of oil, that usually that percentage is 19 or 20 percent of the time that you actually find the oil, even when all indicators technologically possible to discover are go?

Mr. **Herrera**. No, I do not agree with that.

Senator **Fowler**. What would you say?

Mr. **Herrera**. The odds are going to be much longer than that. It is going to be more difficult to find a commercial oil field on the coastal plain than the 19 percent suggests.

Now, if I may, I would like to qualify that remark, because in general terms, the figure that the government has produced for reserves in the coastal plain are certainly agreeable to us.

We think they are in the right ballpark.

Senator **Fowler**. Which are what?

Mr. **Herrera**. Oh, from 600 million to whatever it was, 9 billion barrels recoverable oil in the upper end. It is going to be within that range.

In other words, you know, it gives you a lot of play to be as optimistic or as pessimistic as you like. But if you are an optimist, you have 9 billion barrels of oil which potentially you can look for, which is a pretty good aiming point.

The **Chairman**. Do you want to compare that to Prudhoe Bay?

Mr. **Herrera**. Prudhoe is about 10, and we are talking about recoverable oil.

Senator **Fowler**. Well, again, I will give you plenty of time, if I have lapsed into comparing apples and oranges. But also the millions, I do not know how many millions, but you probably know of the money that was spent in the Beaufort Sea.

With all of those projects about all the oil that was there, it turned out to be untrue, did it not?

Mr. Herrera. At the moment, that is correct. There is always a potential for a surprise. I mean, Prudhoe Bay was a surprise, and obviously, it was a very pleasant one.

Senator Fowler. But how much money has already been spent, would you estimate, in the Beaufort Sea, in exploration, looking for a surprise?

Mr. Herrera. About $6.5 billion over the last eight years, which is a lot of money, and it is that sort of experience that leads me to suggest that a one in five chance of finding a commercial oil field on the coastal plain is rather optimistic.

Senator Fowler. It is rather optimistic? It could be 1 in 10, or 1 in 15, or 1 in 100?

Mr. Herrera. Exactly. However, I would agree that the chances of finding a commercial oil field are very good indeed, much better than practically any other area that is remaining open to or available to exploration?

Senator Fowler. Why do you say that? Compared to the Beaufort Sea, why are the chances there better than in the Beaufort Sea?

Because as I recall again the testimony about the Beaufort Sea, it was rosy.

Mr. Herrera. That is correct. But the reason I say that is, really, geological, and also, economics is put into the picture also to an extent.

You cannot ignore economics. I mean, you have to pay for the exploration before you make a discovery. The initial picture, which I think you are referring to offshore in the Beaufort Sea was equally rosy in that we were forecasting that the geology on shore at Prudhoe Bay continued offshore into the Beaufort Sea.

And the famous, or infamous, depending on your viewpoint, Mukluck well was a Prudhoe Bay type prospect. We put in, industry spent, whatever, $1.6 billion drilling that well, and found the prospect to be devoid of oil; a great disappointment.

Actually, our geological prognosis was very good. It was very accurate. What we were expecting happened, with the exception of the lack of oil.

Now, I know that is important, but for a geologist, that means something.

Senator Fowler. And I assume it means something for an oil man too.

Mr. Herrera. That is right. Our geological prognosis of the coastal plain of ANWR is equally optimistic. But there is always that final uncertainty. Unless you drill a well in the ground, you do not know the answer.

And I would suggest that we cannot go in there prepared to drill five wells and say, okay, we have got our one in five chance. We have exhausted that, and now that is the end.

We have got to go in there and be prepared to drill based on the complications of the geology 20 or 30 wells before we can say there is no commercial oil in this area.

So my answer is one in 30.

Senator Fowler. Then of course as that factor multiplies, that brings into harm's way, for lack of a better description, more of the questions concerning environmental impact, and whether or not this region, for whatever reasons, whatever public policy reasons, we decide should be used, or should not be used, does it not?

Mr. HERRERA. I would argue not, sir, with due respect. And I will base my argument on what you will see when you go up to the North Slope and visit, for example, this KIC well location drilled within the geographic light line of the arctic coastal plain.

We do now have the probability of leaving no footprint behind on an exploration well in the tundra. And while you might be able to recognize that a well was drilled at that site, when you visit it yourselves, you will have a hard time recognizing it.

And you will certainly, I think, clearly identify that there are still a few little indications there, but in the year when the new summer's vegetation mat grows, it is going to be gone, and there is no footprint left behind.

Now, if we can do it once, there is no reason in theory why we cannot do it 29 other times. So I would argue that we really have the capability of drilling 30 exploration wells without adversely affecting the environment.

Senator FOWLER. Let me just say again, with equal respect that you gave me, that I cannot accept the leave-no-footprints-behind analogy.

We leave the drilling, the well itself, aside. But the toxic waste and the damage to either that partial, or however you want to describe it—and that is one of the arguments is, will be there.

You cannot refute—even you said it is hard to build a reserve pit without leaking. You conceded, though you made a very persuasive argument for minimal damage, due to what you described as the advance of technology and the lessons learned.

And I thought you did a very fine job. There is no refutation to the fact that if you are going to have industrial development, you are going to have some toxic or hazardous waste that will escape into the ecosystem.

We will be debating a long time as to the extent of that damage. But I say, with all due respect, and then I will let you respond, you know, that is not an intellectually sustainable point.

A woman takes a birth control pill. It may or may not damage her, but it does prevent the natural ovulation of a system that either nature or the good Lord designed.

If I take an antibiotic, the chemical goes into my system, and it causes the system to react in a different way than had that chemical not been introduced into my ecosystem.

So that when Mr. Mahoney or others, whether they have been there or not, when we find in the tundra the residue of industrial development, you have an effect on the ecosystem that we do not know, four, five, ten, fifteen, or twenty years from now what the extent of that will be.

I would hope that you would concede that.

Mr. HERRERA. Mr. Chairman, Senator, we must not mix up our discussion now—is about exploration and exploration wells. We must not confuse those with development wells and development reserve pits.

Those are permanent and are very different. The exploration well that you hopefully will be visiting and seeing, or the well location, did not have a reserve pit. It had a hole in the ground, which is a safety factor which could have been used in an emergency.

Senator **Fowler**. Well, I will concede that just for the sake of argument right now. The whole purpose of drilling the well is to develop, to move on and to find oil and everything that is going to happen.

So that begs the question, if we are going to try to limit the concept of our discussion to just what the one development will be.

Mr. **Herrera**. But I thought that we were discussing the 20 or 30 exploratory wells. And the position that I have is that one can drill those without adversely affecting the environment.

I admit, as you identified correctly, that when you have a permanent presence there in a production phase, there is undoubtedly going to be an effect. There are going to be many effects.

Senator **Fowler**. But that is the argument, is it not? With all due respect, we are not up there just for—we do it just to have fun drilling some development wells.

We are hoping that we are going to find the oil, or we are not going to be there in the first place, are we?

Mr. **Herrera**. Of course we are. But we have this sort of dilemma up front. Everybody says there is a good chance of finding oil, but nobody can say with certainty until we actually go and drill the required number of exploratory wells, that answer will not be available to us.

And therefore, decisions pertinent to a permanent production facility cannot be made now. Not until we know that we have a viable oil field there can those decisions be made realistically.

What I am saying is, that the opportunity to get to that state of knowledge that you know is available to you without damaging that environment. The exploration phase will leave no footprint behind.

Senator **Fowler**. Well, my time I am sure is about up. So let me ask you this last question.

What are the compelling public policy reasons for going forward with this in ANWR?

Mr. **Herrera**. Mr. Chairman, Senator, my own opinion is that the compelling public policy reasons are domestic production capability of crude oil; are a growing dependence on imported oil; and as one projects this situation into the future, the realization that the further one goes into the future, the more certain it is that those imports are going to have to come from the Persian Gulf.

Senator **Fowler**. Thank you, Mr. Chairman.

The **Chairman**. Just to develop this point about the difference between exploration and development, as I understand your point, Mr. Herrera, and I would like Mr. Mahoney to respond to this after you amplify on it, you are saying in effect that we can determine whether or not there is oil there through 17 or 20 or whatever the small number of holes is, that exploration phase does not interfere with the environment to the same extent that the development phase does; that in effect you can run that 15 or 10 percent or whatever that percent of finding is, up to 100 percent, or down to zero percent, without in effect interfering with the wilderness value.

Now, if I stated that incorrectly, tell me. And would you therefore explain why that is; what seasons of the year you drill; why it does not interfere with the caribou?

And then let me ask Mr. Mahoney to respond to that.

Mr. HERRERA. Routinely over the last years, on the North Slope of Alaska, obviously principally on State acreage, all exploration has been done by decree and by choice in the winter time.

A lot of this does not sound very logical. The reality is, it is much easier to operate in the winter time with the cold temperatures than it is in the summer time. It is easy to move around without damage to the environment, and so on. And so an exploration phase in ANWR would, by choice of the oil companies, and no doubt by the wishes of the managing Fish and Wildlife Agency, take place in the winter time.

And that is one of the reasons—there are many others—that is one of the reasons why its impact on the environment is negligible. The animals are not present, or the vast majority of animals are not present, in the winter time. Those that are, such as polar bears, can be more than adequately protected.

This has happened routinely on the North Slope over the past 20 years.

And so one has the capability of achieving a no impact exercise.

The CHAIRMAN. Would you agree, Mr. Mahoney, that you can get in effect a free look-see without interfering very much with the wilderness values?

Mr. MAHONEY. No, I would not, Mr. Chairman.

The problem here is twofold. One is the environmental impacts, and we have spent some time talking about water availability, or lack of availability, and we have talked some about gravel, and we have talked some about toxics and reclamation.

These things come into play whether we are talking about exploratory wells or development wells. And the degree of environmental degradation for exploratory programs is not as great as the environmental degradation of full on line industrial facilities.

But there is degradation. Wilderness is lost. The animals are affected.

The CHAIRMAN. What kind of percentage of degradation, if you can quantify it?

Mr. MAHONEY. I do not think I can quantify it. I can only say that some of the facilities that would be needed, for instance, if we decide to desalinate seawater, we are going to have to build a facility.

It is going to be real buildings. It is going to be real gravel. It is going to be real ports. We are going to have to be flying in hundreds of planeloads of material.

And while the exploration drilling itself is going to go on in the winter time, I do not think you are going to be able to dredge out your gravel pits and fill them with water in the winter time.

These things are going to have to happen at other times of the year. And likewise, as the Department of Interior says, if you want—if the industry chooses, for its own economic reasons, to drill year around, then it is going to have to begin to use gravel and other environmentally damaging landscape changing methods, which will be quite comparable in their environmental impacts.

Let me, I cannot quite resist, the polar bears, the wildlife, the caribou are there one part of the year, and the industry has sometimes complained that the State has had restrictions too much on the caribou.

The musk oxen are in the riverbanks that we are talking about mining. The polar bears are there. These are the only sites in the north coast of Alaska where the polar bear, which is essentially a marine mammal, like a whale, these are the only places where they are denning on shore.

We had an unfortunately where even during the seismic operation, just running those big heavy track vehicles, Rollogons, I think they are called, across the frozen tundra, we disturbed pregnant polar bears and believe that resulted in the abortion of polar bear cubs.

This is for an animal that we believe should be on the endangered species list, an animal whose populations is very, very much in question, and an animal that is certainly going to be affected by the decisions we have already made in the Beaufort Sea.

But finally, we have a legal or a political question. The industry is not asking for permission to explore. Secretary Hodel is not looking for an opportunity to explore. He is asking for a lease. And when you grant the lease, you grant rights. And as we know from our experience in the lower 48 states, it is pretty hard to change those rights after the lease has been granted.

The CHAIRMAN. Yes, but you would agree that 10 percent or 19 percent becomes 100 percent, it changes the equation somewhat.

The answer may still be no, but it is a different question. If you know there is oil there and it can be developed, then you have a different value, do you not?

Mr. MAHONEY. Well, the barn door is opening. And one you have described it, S. 1217 flings the barn door open very quickly, and says, go, do leases. This environmental impact statement is legally valid; go to it.

And all decisions are essentially made by industry based on not what our best hopes that it might be, but what is cost-efficient to industry in developing a field.

Chairman Jones over in the House Merchant Marine Committee has talked about a government exploration bill, which we opposed for two reasons. One, we believe it will result in unnecessary environmental harm to an area which is a de facto wilderness, a smali "w" wilderness, and an integral part of this larger undisturbed ecosystem, and we do not want to touch it. We do not want to open the door slowly.

But the industry does not like that approach either. You only have to look at the national petroleum reserve, where we went from a government exploration program to a leasing program.

We never found anything over at NPRA, despite estimates that were I gather much greater than the estimates of probability that we discuss here.

But the government did an exploration program over there, and the industry was not satisfied. The industry was not satisfied until it got a lease.

And finally, in 1981, we allowed leasing in the national petroleum reserve, and the industry got to spend its own money exploring, and ultimately, found nothing as well.

But at that point, we had granted private rights, and we had ended the public decision.

The CHAIRMAN. Mr. Herrera, you were shaking your head?

Mr. HERRERA. Well, I was just thinking what an educational experience Mr. Mahoney's trip to Alaska is going to be. He is going to find out the difference between an exploration well and a production scenario, and such like commonly understood things, Mr. Chairman.

But basically, he talks about NPRA. There have been 120 wells drilled in that area. And anybody that flies over that huge region of whatever it is, 23 million acres, and looks out of an airplane, that is the only way to see it, it is so big, and says that this is not a wilderness, is out of their minds.

Of course it is a wilderness, despite 120 wells.

Right adjacent to the coastal plain of ANWR, we have got the Northern Yukon National Park. There is still active oil and gas leases within that national park. The Canadian government apparently does not mind this.

There have been wells drilled, exploratory wells drilled, on the coastal plain of their side of the border. And certainly, if you talk about the caribou and so on, there have been about 60 wells drilled on the Canadian side of the border within the range of the porcupine caribou.

The CHAIRMAN. Well, to come back to the question, though, why is it that exploration is different in water quality and gravel requirements and gravel roads and disposal of cuttings and all of these things?

Is it just because there are fewer wells before you go to the development phase? Or does it make a difference that you are drilling in the winter time? Or do you dispose of it differently? Or do you have a little less in the way of requirements?

Mr. HERRERA. Yes, you have a temporary situation, one well on that location. So that gives you all sorts of flexibility as to what you will use for a pad.

You drill in the winter time, and you make sort of a cocalculation that this well is going to be finished before breakup. Therefore you can use an ice pad that simply melts at breakup, at the end of winter, and disappears. No indication of where you have been.

Or you can use a timber pad as was used in the KIC well, take up the timber pad, reseed underneath it, and there again——

The CHAIRMAN. So you do not need gravel to drill on?

Mr. HERRERA. You do not necessarily have to use gravel.

The CHAIRMAN. Do you need a gravel road to get into your site?

Mr. HERRERA. You are not allowed, by State regulation at the moment, to use gravel roads for exploratory activity.

The CHAIRMAN. Can you put trucks over the tundra without building an ice road?

Mr. HERRERA. You build ice roads. And they melt and they leave no footprint behind.

You dispose of your mud by injecting it down the annulus of the well. You cart off your cuttings to some approved location, because there is not much bulk of cuttings. So you take everything away with you.

Senator FOWLER. Would the gentleman yield?

The CHAIRMAN. Yes.

Senator FOWLER. Is it not true, and correct me if I am wrong—my memory is a little hazy here—that there were problems? Did you not have to have a six-inch layer of—I mean at Prudhoe Bay, did you not have to have a six-inch layer of snow before putting the main earth-moving vehicles across in order to protect the permafrost?

Mr. HERRERA. That is correct.

Senator FOWLER. But it did not work, and that six inches did not protect the permafrost, and the scars are still there, are they not?

Mr. HERRERA. Senator, if I may, you are correct, there are scars in the middle of Prudhoe Bay from 1960 or pre-1960 days; certainly the early 1960s, which were made in the summer time, not in the winter time.

That is why they damaged the tundra.

Senator FOWLER. Thank you. If I may still—all of our questions have been in the same area. If we are just talking about exploring wells, that is like paying your money to go to the movie and saying you are not going to watch the film.

Senator MURKOWSKI. It depends on whether there is a film.

Senator FOWLER. Yes, but the point is, the whole purpose of this exercise is the assumption that oil will be there, and developing wells will ensue.

And what damage that will be to this amorphous concept that we call wilderness, the question, the public policy question of this committee and the country is not whether or not, as an intellectual or a technological exercise, to see whether we can drill exploratory wells without leaving any footprints.

The CHAIRMAN. But it is valid to know what the difference is, just as it is valid to ask the question, would you develop Prudhoe Bay again if you had to do it in the same way?

And the answer to that, you say, is maybe. Even Mr. Mahoney would say maybe, because we know we have got 20 percent of our oil from there, and that is a different question than saying, will we sacrifice our last wilderness on the chance that we may have oil.

It really is a different question. So you want to know what the damage is from your look-see.

Mr. MAHONEY. Mr. Chairman, we believe that we start with a known value, the wilderness, and we have an unknown value, the potential energy.

But it is our contention that in trying to learn about the unknown value, you damage and perhaps destroy the known one, and we do not believe that is a tradeoff that is acceptable.

The CHAIRMAN. Let me ask one final question, which is this.

A lot of both your testimonies has been on the question of the technological improvement of drilling methods; of the fact that on the island you required only a million cubic yards of gravel, whereas Prudhoe Bay had required many times that.

And I guess the general question is this, Mr. Mahoney. Do you concede, and if so, to what extent do you concede, if at all, that technology has improved on methods used at Prudhoe Bay?

And does that assuage your concerns at all?

Mr. MAHONEY. I believe that technology is improving, although I must say, with regard to gravel, I would go back to saying that we are referring to the same document you are, and not the 1002 report, and not the promise that it will be less harmful than the 1002 report says.

The document which I will be making available to you, or can make available to you, from the Alaska Oil & Gas Association, to the State of Alaska, regarding its environmental regulations, review of State stipulations and costs affecting industry operations, dated April 6th, 1987, says, page 45, item 12, exploration facilities must be temporary and must not be constructed of gravel.

We assume the definition of drilling pad includes associated storage and support facilities. If not, this restriction eliminates the only practical material available for temporary storage and support facilities.

Further, it could preclude exploration on a year-round basis. We have a lot of reassurances that exploration can take place in the winter with less damage than if it takes place year-round.

But certainly it is an economic decision which faces the Congress.

Now, I would turn it to you, Mr. Chairman. If the industry's record is improving, and if the longer we develop the State lands west of Prudhoe Bay, and the more experience we find out at the Beaufort Sea, the better and better it gets, and the less environmentally harmful it gets, should we not wait and come back and explore the question of whether we should open up this last wilderness area later with that knowledge in mind?

Should we make the public policy decision based on that promise? We have already made a number of public policy decisions in opening of the Beaufort Sea, and the State offshore lands to leasing. And the areas between Colville River and the Canning River.

We have made those decisions whether industry gets better or not. Those are not private leases. If the oil industry is getting so much better, wait a decade. Let us see whether some of these reports of toxic waste and reclamation are as bad as we say or as good as Mr. Herrera says.

We believe the case for the arctic coastal plain is such a good case that this committee should tomorrow, next week, vote to make it a wilderness area.

We persuaded the House, we think, to make it a wilderness area once before, but we could not quite persuade the Senate. But we believe the case is very strong.

However, if you are not persuaded that it should be a wilderness area, we suggest you wait and see who is saying—you know, see whose predictions come true. See how big the Prudhoe Bay facilities get. See if we avoid environmental disasters in the future.

See what reclamation is like when Prudhoe Bay begins to shut down. And then make up your mind. Does that record say that the environmental harm in 2015 is a lot better than it was back in 1907, and it is a good thing we waited until now.

The CHAIRMAN. Would you like to respond to that, Mr. Herrera?

Mr. **Herrera**. Well, if I may, Mr. Chairman, I hope Mr. Mahoney's predictions are better than they have been in the past, because they have all been wrong in the past.

Mr. Chairman, may I with your permission just revert back to the exploration discussion we were having, because I think it is very important.

I am not advocating for a moment that industry would support exploration only in order to find out how much oil, or whether there is a major oil field there, because I do not think industry will.

They are not going to put in whatever it takes, a billion dollars or whatever, with no guarantee that if they find something, they cannot reasonably exploit it afterwards.

What I am saying is, though, that you, making this decision, without knowledge, without specific knowledge of where the oil is, have a very hard time indeed.

You cannot ask the question of where is the oil, what is the oil field going to look like, because nobody, literally nobody, can give you the answer. We do not know.

The only way of getting that answer is to allow leasing which allows development. Then you get to the situation where the discovery has been made, and at that time, you go through a reasonable public process, fullscale environmental impact statement, perhaps a more rigorous and onerous one than normal, to zero in on the specifics of your development, and then you make your decision where that development is to go ahead, in what fashion, at that location.

You cannot make that decision until you know those facts.

The **Chairman**. I had said that was the last question, but let me ask just one more. [Laughter.]

I think I have alluded to this before in this committee, but in the Texaco-Pennzoil trial, Texaco did not put on any evidence at all as to the amount of damages, because they did not want the jury to think they had less confidence in their case.

So all the evidence as to damages was on the side of Pennzoil, and they ended up with a judgment of about $13 billion, where most legal experts tell me that if they had really put on the evidence, that the actual damages were a lot less than that.

The point of that is that sometimes even though you strongly believe in your side of the case, it is best to put in evidence as to, in that case, the amount of damages; in this case, evidence as to means of mitigation, just in case the people on the committee should decide that they want to develop.

Do you have any advice to us as to how we should get—how we should go about getting the information as to how to structure some rules, if there should be any additional rules?

I know your advice is, no, keep it a wilderness. But how should be deal with that problem of what if?

Mr. **Mahoney**. You should deal with that problem. But I believe you are going to need a lot more information than you now have.

The piece of paper from the Fish & Wildlife Service that I have been referring to all day indicates that it was the Fish & Wildlife Service internally that was arguing, years ago, that the 1002 report, that was under construction by this administration, was deficient in its preparation in its assumptions on mitigation, on its assumptions on reclamation, in its assessment of gravel and water, in its assessment of toxic waste.

The agency knew it. Somebody decided, someone up the ladder, decided it was not necessary to get you that information.

The Environmental Protection Agency wrote the Department of Interior in June and said that the entire EIS was so flawed in its analysis, its analysis was so unable to support its recommendations, that if it was a normal instance, they would recommend it be withdrawn.

But as it was not a normal instance, they recommended that the recommendations be withdrawn.

And when the Department of Interior tried to say, well, EPA did not really understand; this was just sort of a big programmatic EIS, the Department of Interior did not want to do an EIS in the first place, it was the Federal courts that ordered them to do it.

But EPA did not just come out of nowhere and say these are problems. EPA had participated in this process throughout as well, and all of the objections they had brought up, and all of the analyses that they said should be done, were not done.

Instead, we have relied on a lot of assumptions; assumptions that Prudhoe Bay is a success; assumptions that we will find ways to get the water; assumptions we will find ways to get the gravel; assumptions that are not documented.

Not that people did not say they should be documented. And we would say to you, you should learn about mitigation, and you should demand it from an impartial source, not from a reassurance of a party that has something to gain depending on your decision.

The CHAIRMAN. Well, I know the National Wildlife Federation has suggested that we delay the matter and make a study, I think for a year or two, and get the panel to make certain recommendations.

But short of that kind—and I know that is not your position; your position is no—is there anything we can do, or what would you recommend we do? Let us assume that at some point we are going to take a vote, whether it is later this year, or early next year, as to any kind of restrictions?

Mr. MAHONEY. Well, if we were more trustful of the Department of Interior, I would suggest that you go back to the Department of Interior and ask them to fill out the 1002 report, not just looking at this little slice of land, and taking the reassurances of what the Prudhoe Bay experience is, but actually looking at the cumulative effects of all North Slope development and Canadian development, maritime development, as well, and look at what that says to the overall environmental impacts, and the overall styles.

We are not very trustful of the Department. The Department took out the worst of the impacts it reported in the draft, and made them more benign sounding in the final. The Department is going the wrong direction, we think.

But we would suggest that you conduct hearings where experts that do not have a stake in this are brought before you to discuss what is mitigation, what is not.

We would suggest that some of the experts that the NRDC and the trustees of Alaska have talked in the Alaska Department of

Environmental Conservation or the EPA be brought forward; the Army Corps of Engineers be brought forward to tell you what their assessment is.

It will be hard to get below that political layer and actually find the expert, but you could do that. And if you did, you would learn a lot more about mitigation and whether it really exists.

The CHAIRMAN. Well, I guess the question is, should we try to write those kind of things in the statute, or ideally, should it be done by a Department of the Interior that one trusts, and say, drilling is hereby allowed under such terms and conditions as the Department of Interior should decide?

Mr. MAHONEY. Well, if it were my druthers, and the Congress was not willing to agree with me on wilderness, I would hope the Congress would throw up its hands and say, we just do not know enough, and we did not get very trustworthy administration.

We are going to get another administration here. The last administration said this area should be wilderness. This administration says it should be leased completely.

Let us get some more experts. Let us get some more information in. I do not think you necessarily have to pass a law to do that.

But I do think the burden of proof is that you can do that safely. And I do not think that burden has been met.

The CHAIRMAN. Mr. Herrera, if there are going to be regulations put on, how should they be done? What would you recommend, if anything?

Mr. HERRERA. Well, Mr. Chairman, they should be practical, unless the objective of the regulations is to achieve a political aim, which is different than the ostensible result, they have got to be made to work, both to protect the environment, and to allow the desired activity to take place.

That is not too difficult to achieve, quite frankly. There is a lot of experience on how to work in the arctic available now. So that experience has got to be translated into best estimate of environmental protection.

And that sort of stipulation could easily be put into a bill.

But the stipulation, if it is gold plated, or made too extreme, then obviously the end result is no activity. And that is the sort of line that has to be drawn, and care taken not to indulge in overkill.

The CHAIRMAN. Well, I think at some point, this committee has to go through some discipline to get that information, unless we just want to make an up or down decision.

And I would ask for your advice as well as others on what we might do in terms of hearing and getting in witnesses for that purpose.

Senator Murkowski.

Senator MURKOWSKI. Thank you. I wonder if I might pass to my colleague from Georgia some pictures that I think bear some reflection on his concern.

These were taken as a consequence of the drilling of the Kaktovik well, which was the only well drilled in the 1002 area. And the drilling occurred in the fall of 1984, 1985.

These pictures were taken in June. And we can get an identification. But they give you some idea of the area. This is the area where the drilling actually occurred. And it shows the cleanup, and the actual depository which looks a little bit like a molehill in comparison to a pan that was left.

We will get proper identification on these, because I think they throw some light, if you will, on the issue with regard to an exploratory well and what is left after it.

I have for the record the specific identification as submitted by Chevron USA, Mr. T. Cook, and the photos are numbered. And there is an explanation.

[The material follows:]

Chevron

Chevron U S A Inc.
6001 Bollinger Canyon Road, San Ramon, California
Mail Address: P.O. Box 5050, San Ramon, CA 94583 0905

Land Department
Western Region

July 20, 1987

Chevron Drillsite
KIC No. 1 - Alaska

William P. Horn
Assistant Secretary for Fish
and Wildlife and Parks
United States Department of the Interior
Washington, D.C. 20240

Dear Secretary Horn:

I understand that Messrs. Alvin L. Ewing and Robie G. Russell of the Environmental Protection Agency have shown you and members of your staff (and others in Washington, D.C. and Alaska) photos which are alleged to depict the current condition of the KIC No. 1 drillsite. I have been advised that these pictures show extreme amounts of debris and litter including fuel drums and sheens of oil on standing water.

On July 10, 1987, I asked Mr. Ewing to show me the photos which he had previously shown to you and others. I was initially shown three photos of the drillsite, none of which showed litter, discarded fuel drums, or oil sheens. When I asked about any other photos which purportedly depicted "a deplorable mess" at the drillsite, Mr. Ewing produced additional photos showing litter and discarded fuel drums, which were apparently taken elsewhere. Mr. Ewing stated that he had not intended to represent these latter photos as pictures of the drillsite.

There seems to be a substantial misrepresentation of facts concerning our KIC No. 1 exploratory well. Mr. Don Oliver of NBC News on Tuesday, July 14, 1987, completely misrepresented the impact of the well by showing a picture of a gravel extraction pit on Barter Island which he said was Chevron's wellsite. The simple fact is that the gravel extraction pit is more than 15 miles from the drillsite. Chevron's operation was in no way connected with the gravel extraction pit. Mr. Ewing was also interviewed on NBC News by Mr. Don Oliver, during which Mr. Oliver stated that the gravel extraction pit was the wellsite.

Enclosed are several photos of the KIC No. 1 drillsite which were taken on June 23, 24, and 25, 1987. These photos were taken by our drilling representative, Mr. M. W. Tweedy, who was on-site to conduct additional cleanup operations and rehabilitation in accordance with our approved Reclamation Plan. A copy of our KIC NO. 1 Exploratory Well Site Reclamation Plan is enclosed for your information. The Reclamation Plan recaps in some detail our prior work on site clean-up and rehabilitation as well as future work which will be undertaken this summer. I should also add that all work has been undertaken as scheduled and to the satisfaction of the Refuge Manager.

With regard to the enclosed photos:

1. This photo was taken on the morning of June 23, 1987, prior to this year's clean-up. The reserve pit is shown in the foreground and the drillpad is in the right background. A few remaining 3" x 12" timbers are in the pad area. Some fragments of foam insulation are in the center of the picture. The scrap timber was burned and the fragments of broken insulation were removed after this photo was taken. Final clean-up and rehabilitation is now under way.

2. This photo shows the status of clean-up operations on the afternoon of June 24, 1987. The pad area is in the center of the photo. The location of the reserve pit is on the right side of the photo.

3. This photo was taken on the morning of June 25, 1987. The reserve pit is to the left and the pad area is to the right. The pipe in the center of the picture is a survey marker post which is required by regulations of the Alaska Oil and Gas Conservation Commission. The marker post is at the location of the abandoned well.

4. This photo is a close-up of the capped reserve pit showing re-seeded grass growing on the covered pit. The reserve pit area was first re-seeded and fertilized during June of 1986.

5. This photo shows the extremely small size of the foam insulation pieces which were picked up. Note the ball-point pen included in the picture for scale. In reviewing Mr. Ewing's pictures, I noted that he had a similar photo. However, his photo provided no sense of scale.

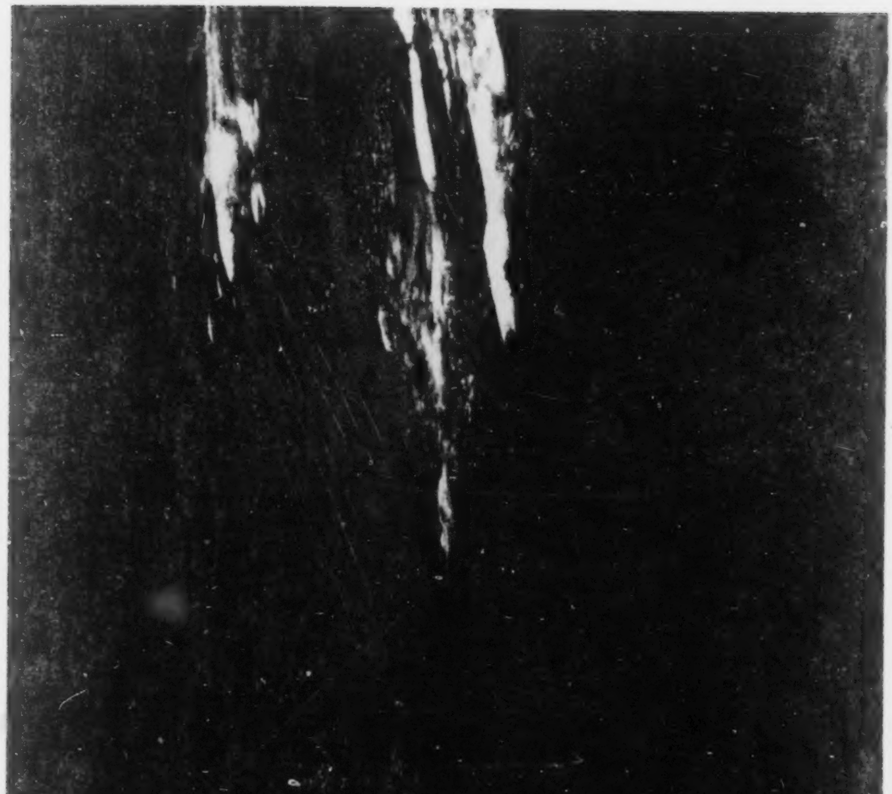
I hope these photos and comments help you understand the current status of the KIC NO. I drillsite and Chevron's diligence in working with the U.S. Fish and Wildlife Service to see that impacts from our exploratory well are minimized. Chevron and its partners are very disturbed by the misrepresentations of our operations. Please contact me if you need additional information concerning the environmental impacts of our KIC No. I exploratory well.

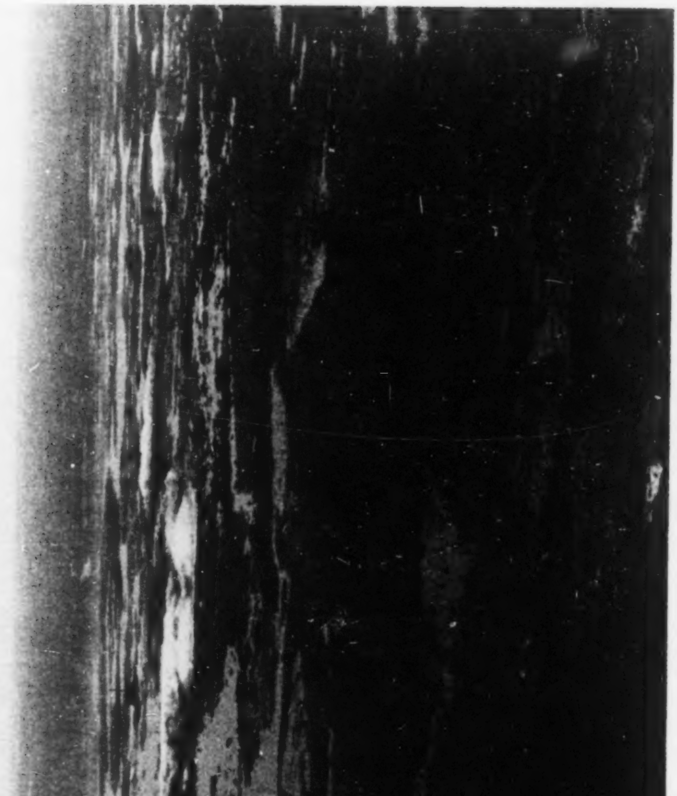
Sincerely,

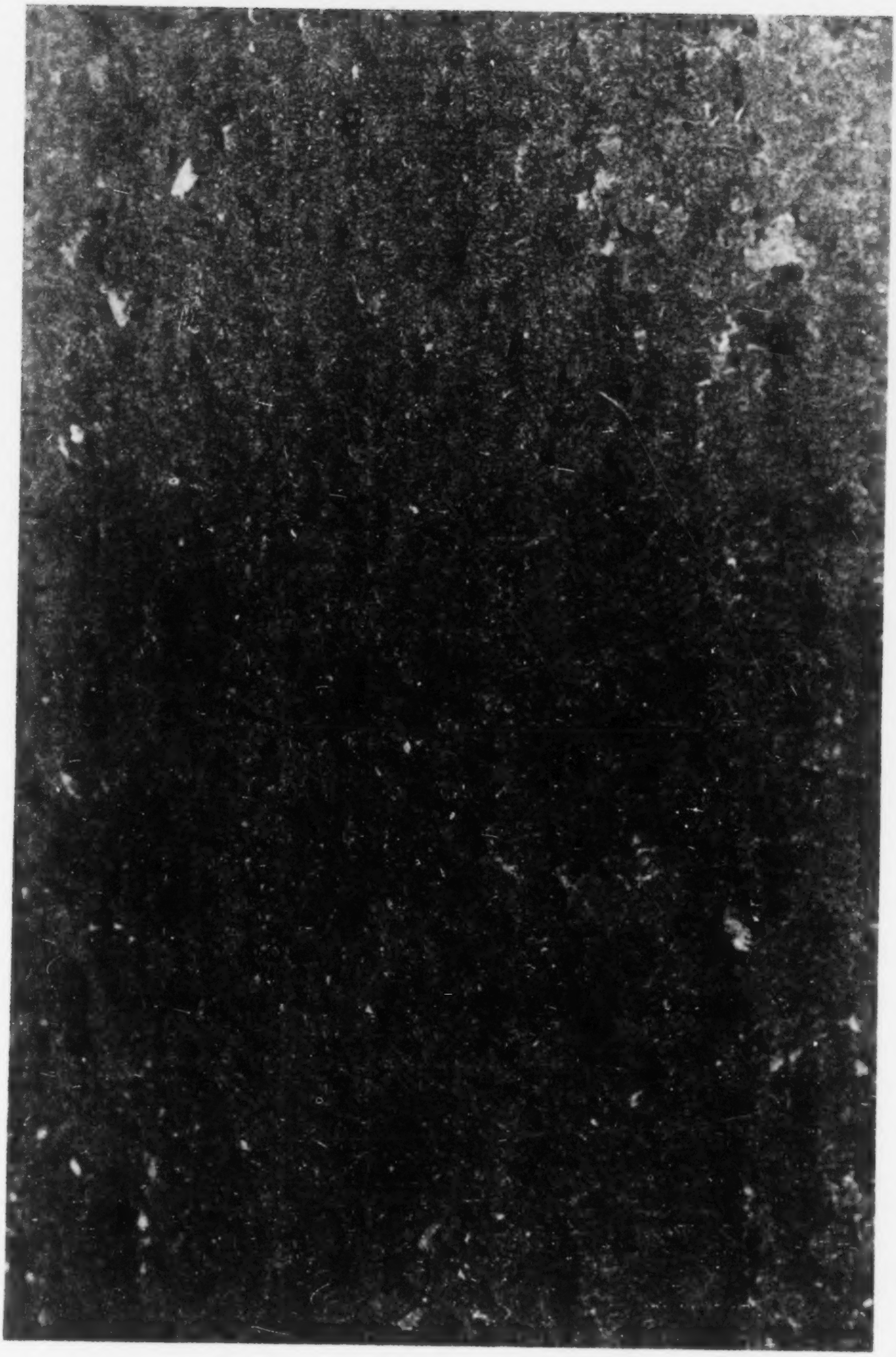
T. Cook
Exploration Representative-Alaska

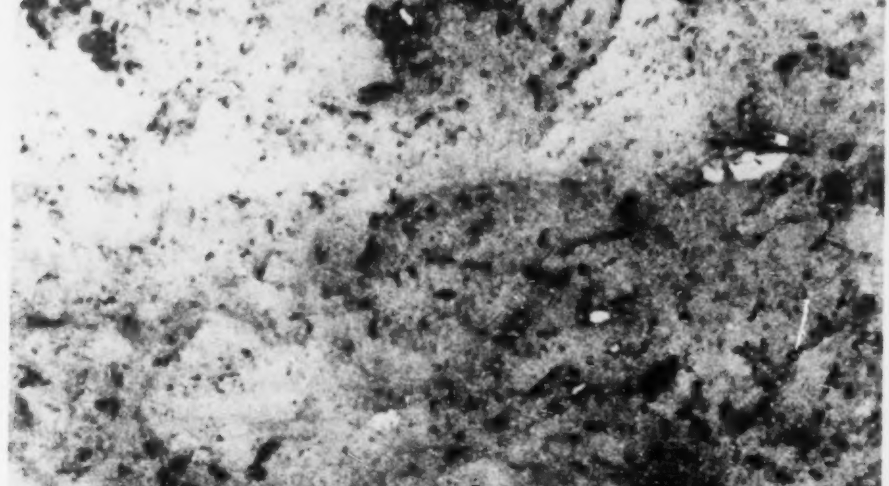
TC:mw
Enclosures

cc: Walter Stieglitz, U.S.F.&W.S. - Anchorage
Glenn W. Elison - U.S.F. & W.S. - Fairbanks









The CHAIRMAN. May I interrupt at that point to say that I have to go back to the office, and I want to ask Senator Fowler if he is going to be here to preside for whatever additional questions there are.

Senator FOWLER. Well, I think it is time to quit. I do not have any other questions. Let us just let Frank finish.

Senator MURKOWSKI. Thank you, Mr. Chairman. I would like to talk about a classification that has been used in this hearing that I think has some very serious consequences.

I would ask Mr. Mahoney if it is the contention of the Alaska Coalition, the Sierra Club, and others, that the traditional drilling waste, drilling mud, et cetera, is considered toxic by your interpretation or that of your organization?

Mr. MAHONEY. Yes, it is certainly toxic. It contains heavy metals and carcinogens.

Senator MURKOWSKI. I know what it contains. But you would state it as toxic?

Mr. MAHONEY. Yes, drill muds are exempt from the Resources Conservation and Recovery Act, RCRA, not because they are not toxic, but because the oil and gas industry was successful in exempting them from RCRA.

Senator MURKOWSKI. And you think they should be classified as toxic and treated as such?

Mr. MAHONEY. Yes.

Senator MURKOWSKI. Are you aware of the potential consequences of that kind of classification?

Mr. MAHONEY. I am aware that EPA is studying the toxicity of drill muds under RCRA, and is going to make a recommendation to Congress as to whether they should be included in RCRA or not.

And we certainly hope they will be included, because we have already had instances, in the North Slope of Alaska, where toxics have leaked into the atmosphere, and the consequences are as yet unknown.

Senator MURKOWSKI. Well, I think it is fair to say that drilling muds are drilling muds. They are conventional chemical complex of mixtures, the base of which is borite, which is a natural mineral found in various areas of the United States.

As a matter of fact, it is found in Alaska. There used to be a small mine near Petersburg underwater.

But the question is to Mr. Herrera, and I am asking you as a representative of the industry, if drilling, conventional drilling muds, which are not unique to Alaska, they are prevalent in Louisiana and every oil producing state, were deemed toxic, what would that do the industry and the consumer, in your opinion, from the standpoint of the manner in which you would have to address that, and perhaps go back and initiate areas where drilling mud has been disposed of in the conventional manner, meeting state laws which I believe for the most part are the criteria subject to meeting EPA qualifications.

Mr. HERRERA. Mr. Chairman, Senator Murkowski, it boggles the mind really, if it were sort of back dated, it would just cost billions of dollars to deal with that.

Senator **Murkowski**. I have heard that the domestic industry in the United States would no longer function. Is that a realistic threat?

Mr. **Herrera**. One could certainly contemplate that, yes.

Senator **Murkowski**. Well, I would appreciate, Mr. Chairman, since this is kind of an official record and official debate, if the record could reflect indeed the consequences if it were determined that conventional drilling muds, not necessarily attributed to Alaska, but overall, were considered toxic, whether we would have a domestic oil industry, or whether we would be totally dependent on imported oil.

Would that meet with your approval?

Mr. **Mahoney**. Senator Murkowski, may I expand on my answer a little bit? The question of whether something is toxic or not is a question of chemistry.

Senator **Murkowski**. I understand.

Mr. **Mahoney**. And biology, and not of law. Whether it is regulated as toxic or not is the question of law.

Now, we have a superfund law today because for dozens of years, or decades, or perhaps even longer than that, we disposed of chemicals without understanding their true toxicity.

Now, just because it was legal to dispose of them does not mean it was toxic. They were toxic, and just because it would have been expensive for the industry to have disposed of them differently does not mean that we should not have done that.

Because we are going to have to pay for the cleanup of those toxics now, and industry is having to pay for it, and the taxpayer is going to have to pay for it.

So I would suggest that if something is toxic, we ought to know about it, and we ought to write our laws accordingly.

Senator **Murkowski**. Well, I am sure Mr. Herrera could respond to that. But it would be my evaluation that there are indeed toxic chemicals in the conventional drilling waste or residue.

But that does not necessarily imply that drilling muds and waste should be classified as toxic, and I think that is the question. And we have to recognize certain realities here.

We all enjoy the fruits of energy. As a matter of necessity, we are all aware that there is a certain compromise in developing any form of energy, and whether we consider the concerns expressed by my colleague from Georgia on the fact that you are going to have an environmental impact of some kind, compared to nothing if you are going to explore for oil in the 1002 area, the realities speak for themselves.

We are either going to have certain bounds within which the industry is going to be able to operate in the United States, or the consumer is going to pay an extraordinary amount, or we are going to depend on imported or alternative energy sources.

Now, Mr. Herrera, this matter of toxicity is important, because it is going to affect your industry. It is going to be before the Chairman and this committee.

The Environmental Protection Agency is addressing the issue now. But the term has been used, and I think a little unfairly, that in Alaska we have something unique associated with drilling.

Hell, it is no different than drilling anyplace else. They use drilling muds. They have to get rid of it. They have to store it. There is a concern about it.

Mr. **Mahoney**. I am suggesting, Senator, that the cost of cleaning up toxics should be considered by the public as an overall cost that the public may ultimately have to bear.

Senator **Murkowski**. I agree with you. But I suggest that we have yet to determine that drilling wastes collectively are classified as toxic.

They are still called drilling wastes, and that is the question.

Mr. Herrera——

Mr. **Mahoney**. Well, they are subject to other laws, such as the Clean Water Act.

Senator **Murkowski**. We understand that. That is obvious.

Mr. **Mahoney**. That would deal with the disposal of pollutants. I do not think anyone is denying that this series of chemicals is toxic, not even industry.

The arguments may be that they are not concentrated so much as some others, but it may be inefficient from a cost-effectiveness point of view, but I do not think they are denying that these things are not harmful. Otherwise, we would just spill them on the tundra.

Senator **Murkowski**. Well, we do not spill them on the tundra, and I resent that kind of implication that we go out and spill them on the tundra, any more than we spill them on the coast of California.

And your testimony, very frankly, you know I find very colored. And I think it is unfortunate.

Obviously, I am defending the interests of my State. But the generalizations used here that we spill on the tundra I think are totally uncalled for.

There is a concentrated effort in the State of Alaska by the industry as well as the Environmental Protection Agency and the State Department of Environmental Conservation to try and do things right.

And to suggest that this is some kind of slipshod method, I think that the State of Alaska and its efforts collectively take second to none as probably some of the more objective members of industry who work all over the United States could so indicate.

And you know, you indicated, Mr. Mahoney, in your testimony a reference to the fact that industry always does things the cheapest way. The implication of that I find very disturbing as well.

Because let me tell you something, the trans-Alaska pipeline was estimated to run under a billion dollars. By the time all the various governmental agencies who expressed a valid and justifiable and correct concern, including the exposure to earthquakes, the environmental aspects associated with that, that project ran $7 billion.

Now my question to you is, do you not feel that Congress has the capability and the expertise to dictate based on the evaluation of scientific information, not necessarily the cheapest way, and to suggest it has always been done expedient to industry in the cheapest way, I would contrast that by the reality of the pipeline, which was not the cheapest pipeline; it was the most expensive construction project in North America, and it was done strictly to meet environmental concerns that were very justifiable.

So do you see my sensitivity to your general train that says industry is going to do it? This is Congress' job. This is the Chairman of the committee and the rest of us.

To sit there and say, okay, here are the experts, your concerns and that of the environmental community, and your concerns of the industry. But the technology advanced by government, EPA, and so forth.

We are going to suggest, not you, and not the industry or Mr. Herrera, the process that is going to be utilized, and it is not going to be the cheapest necessarily; do you agree with that or not?

The **CHAIRMAN**. Answer yes or no. [Laughter.]

Mr. **MAHONEY**. I suggest that Mr. Herrera has acknowledged that industry makes mistakes and has made mistakes and is trying to do better. I do not deny that at all.

Senator **MURKOWSKI**. But do you think that this committee and this Congress is capable of making that decision?

Mr. **MAHONEY**. I have said to Chairman Johnston and would say again that I do not believe this committee or the Congress has yet been presented with all of the facts.

And in particular, the committee has not been presented with all of the facts about the known waste disposal problems at Prudhoe Bay.

Senator **MURKOWSKI**. I think you and I have both been around long enough to recognize that at certain points, you have to make decisions.

And you and I both know, as Mr. Herrera does, as the Senator from Louisiana knows, that there are elements in here that have testified that want no development of any kind because that is not their interest.

We understand that. But it should not be guised in some subterfuge. It should be said, hey, we are opposed to development in ANWR, or for that matter, anywhere else.

You know, I cannot think—and I have followed the history of the Sierra Club in my State—there has not been one single instance, not one, where the Sierra Club has ever supported any activity in Alaska of any kind of a development nature.

And I defy you to provide me with one single thing you supported.

The problem we have in the State of Alaska, unlike the Chairman's state, is, we are publicly owned. It is owned by all the citizens of the United States, and rightly so. They have a voice in the disposition and dictation.

But you know, when you talk about wilderness, do you know how much wilderness we have in the State of Alaska, Mr. Mahoney?

Mr. **MAHONEY**. 56 million acres.

Senator **MURKOWSKI**. 56 million acres. Fifteen percent of the landmass in our State.

You know, we have another six percent of national forests. Another 12 percent in national parks and monuments. Another 14 percent in wildlife refuges.

The **CHAIRMAN**. Senator Murkowski, I do not want to cut this short, but the witnesses have been sitting in those chairs for 3 hours and 25 minutes, and I think they may have a water problem of their own. [Laughter.]

Senator MURKOWSKI. I think you are probably right, but I will need another 40 seconds to conclude, Mr. Chairman.

The CHAIRMAN. Okay.

Senator MURKOWSKI. So let us keep it in perspective for the minds of the public. Because ANWR is 18,900,000 acres. That is a big area.

And when we reflect, you know, on how big that is, it is bigger than New Jersey and Vermont put together.

Now, what are we talking about taking out and allowing exploration on? 1,500,000 acres. That is the 1002 area.

There is an additional 9 million acres that is a refuge. There is an additional 8 million acres that is in a wilderness.

You know, what is reasonable? You would just as soon have everything north of the Yukon in a wilderness, is that not true?

Mr. MAHONEY. Senator, that was Bob Marshall's desire.

Senator MURKOWSKI. I am asking you.

Mr. MAHONEY. Well, let me answer you. The desire of Bob Marshall in the 1930s was that this is such a spectacular wilderness that it should all be so designated.

I am sure that if I were there in the 1930s, I would have agreed with him. But there were geologists that were exploring on the North Slope of Alaska at that time, and because of that we set aside a naval petroleum reserve.

We established the arctic wildlife preserve in 1960, eight years before the Prudhoe Bay discovery. We did it for a reason, because it was the best place.

And we submit that a land use balance that let the oil industry and the geologists have their say over 1,000 miles of the coastline, and let the wildlife and the wilderness have its say over 100 miles of the coastline, that is not my definition of good balance.

But I would not want to see the pie sliced again.

Senator MURKOWSKI. Well, I would not either. And I would sincerely hope, Mr. Chairman, that this great debate has shown the true merits of the gentleman representing the Alaska Coalition with regard to his attitude toward development.

It is a nondevelopment attitude, associated with ANWR. It is a nondevelopment attitude associated with the oil industry in the State of Alaska.

And I think that that is indeed unfortunate, because it does not represent a well balanced realization of the real world. We have to have energy. We have to explore, or we are going to be held hostage as we were previously.

And this committee and this Chairman have that obligation to try to balance it. And I commend you for the role you play, but it is all one-sided and that is unfortunate.

The CHAIRMAN. Well, far be it from me to defend Mr. Mahoney, because he defends himself very well. And we may or may not take his advice on this committee.

But I would say in defense that the Sierra Club is not in the development business.

Senator MURKOWSKI. It sure is not.

The CHAIRMAN. That does not detract from its credibility. I want to thank both witnesses very much indeed for what I think has been an extraordinarily useful session here with the committee.

I think it has focused in on the real issues more than we usually do. We have not got all the answers in such definitive fashion that everyone will be satisfied with them.

But I think we are groping and developing the truth as best I think can be done, and this has been very useful to us.

Obviously, we are going to have more hearings. We are going to do more investigation, because this is a very, very important issue.

Senator MURKOWSKI. Mr. Chairman, I will look forward to taking Mr. Tim Mahoney out and shoveling a little of that white dust, and looking at the mountains that come right down to the sea, because believe me, they are a long way away.

The CHAIRMAN. And as I mentioned earlier, we would like to get the advice of both of you as to how we might structure a hearing on the question of, if we allow drilling, what kind of limitations should be included in the statute, in the regulations? Who should do promulgation and what should be those limitations?

We would like that advice and will be looking to you for it.

Thanks again to both of you for your superhuman effort today.

The meeting is adjourned until the 9:30 markup tomorrow.

[Whereupon, at 5:30 p.m. the hearing was adjourned.]

[Subsequent to the hearing Mr. Mahoney submitted the following:]

ALASKA
COALITION

'To Preserve Alaska's National Interest Wildlands'

July 27, 1987

Re: Arctic National Wildlife
Refuge

Hon. J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman,

Since the July 22 hearing on the Arctic National Wildlife Refuge, we have obtained additional information on the matter of waste disposal and pollution problems at Prudhoe Bay.

These two articles appeared in the Anchorage Daily News of July 19 and 20. They include information on a previously unreported incident of state cleanup of 500 barrels of leaking oily waste. I hope you will consider them as supplemental to the information presented at the hearing.

We believe that additional investigations will uncover more information about pollution difficulties on the North Slope. Thank you for your attention to this matter.

Sincerely,

Tim Mahoney
Chairman

Enclosures

330 PENNSYLVANIA AVENUE, SE • WASHINGTON, DC 20003 • (202) 547-1141

ANCHORAGE DAILY NEWS JULY 19 1987

7-19-87

Prudhoe Bay — An environmental gem or lurking problem?

By PATTI EPLER
Daily News reporter

First of two parts

PRUDHOE BAY — The midnight sun is hazy red above a silvery skyline that stretches forever across the horizon. In the softening light, Prudhoe Bay is at peace.

Towering oil rigs are still at work, pumping black crude from deep within the earth. From a distance, they seem in harmony with the greens and browns of an arctic summer.

Suddenly, the vista is twisted by fire — flames shoot from huge pipes as natural gas, pressurized by the ages, escapes skyward, burning. The flares slowly subside, leaving clouds of black smoke to hang in the cool June air until, finally, a fog creeps in and hides the changing scene.

Nearly two decades after North America's largest oil field began production, Prudhoe Bay is still somewhat of an environmental puzzle. Is it possible to extract one resource from within the earth while leaving an equally valuable one mostly intact on its surface?

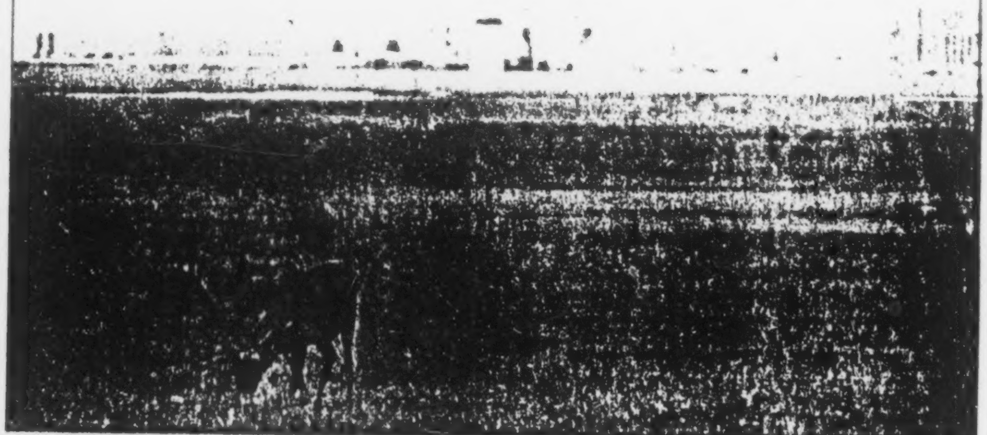
The question is being asked with more urgency these days, as congress wrestles with whether to allow oil development in a part of Alaska still relatively untouched — the coastal plain of the Arctic National Wildlife Refuge.

Some say the North Slope fields are environmental marvels, direct evidence that oil production leaves little lasting mark on the arctic ecosystem.

Environmental groups, who believe any intrusion on ANWR is unacceptable, say that's not true. "Contrary to oil industry claims," says a new report by the pro-environment Alaska Coalition, "pollution problems plague the oil and gas development that has taken place in Alaska's arctic region."

Who's right? A week of touring North Slope oil fields; numerous interviews and the review of dozens of technical reports indicate that the answer, predictably, lies somewhere between.

See Page A-8, **PRUDHOE**



Anchorage Daily News/Eric Hill

One question being asked now is what effect further arctic development will have on the caribou herds and other arctic wildlife.

Deadhorse gives industry black eye

By PATTI EPLER
Daily News reporter

DEADHORSE — The state will likely pay tens of thousands of dollars to clean up leaking drums of oily waste abandoned on a gravel pad here, state environmental officials say.

Several weeks ago, the Alaska Department of Environmental Conservation discovered more than 500 drums of petroleum liquids on a pad leased to Child's Equipment Services, a company that had filed for protection from creditors in U.S. Bankruptcy Court.

Since then, DEC has found several more dump sites in this haphazard community on the edge of the Prudhoe Bay oil fields. The public burden is likely to grow as an economic slump in Alaska's oil patch squeezes service companies off the Slope, their messes conveniently left behind.

Deadhorse is giving the oil industry an environmental black eye, and at a most inopportune time. Oil companies are struggling to convince Congress to allow development in the Arctic National Wildlife Refuge east of here. But environmentalists have found much anti-development ammunition in the mess that is Deadhorse.

The Child's pad is a prime example. It appears that the barrels, as well as tons of

See Page A-8, **DEADHORSE**

PRUDHOE: After 20 years of drilling, area remains environmental puzzle

Continued from Page A-1

"I'd be hesitant to say one way or the other," said Brad Fristoe, an environmental engineer who heads the Alaska Department of Environmental Conservation's North Slope office. "There are things up there that have been impacted that are going to take a long time to recover. But (the area) still produces a lot of the things that it used to and still supports caribou populations and waterfowl populations. The long-term effects haven't really been determined."

Upcoming congressional hearings will focus on the environmental consequences of developing ANWR's coastal plain, about 100 miles east of Prudhoe Bay. The oil industry's record in the Arctic promises to be central to the debate. Pro-development interests wave pictures of caribou frolicking in front of oil rigs, while conservationists display photos of huge pits of oily black waste on fire.

No one knows yet what effects the development of Prudhoe Bay will have 50 or 100 years from now. Prudhoe Bay began in the late 1960s, without the benefit of today's knowledge of the Arctic and before most of the country's environmental laws were in force. Government watchdog agencies began regular field inspections only four years ago; before that, they monitored development from offices in Anchorage, Fairbanks and Seattle.

It's obvious that development has improved with new technology and greater experience by industry and environmental regulators. It's also clear that increasing oversight by state and federal agencies has brought about more sound environmental practices. Lawsuits by conservation groups also have forced government agencies to enforce previously ignored environmental rules.

Regulatory officials say they now have a good understanding of problems at North Slope fields. They say they have learned many things that will help guide environmentally sound development at ANWR.

For the most part, state and federal officials believe that oil development in Alaska's Arctic can proceed with minimal environmental harm — as long as there are tough controls, careful planning and enough money for regulatory agencies to do their jobs.

Chief among the concerns is the way oil companies dispose of hundreds of millions of gallons of oily waste. Officials also question whether the air is being polluted by the massive turbines that run production facilities, and what effect expanding oil field development is having on fish and wildlife

OILY WASTES

By far the most serious environmental problem identified by watchdog agencies involves hundreds of huge pits that hold hundreds of millions of gallons of toxic waste produced during the drilling of oil wells. Some of the pits, especially those built in the early years of Prudhoe Bay, are thousands of feet long.

The pits sometimes leak, allowing poisonous heavy metals and hydrocarbons to seep onto the tundra. In addition, oil companies can legally discharge millions of gallons of water from the pits onto roads or the tundra directly — if the water meets standards set out in state permits.

State and federal officials worry that enough pollutants could accumulate in the tundra to kill plants and destroy important waterfowl habitat or work their way into the food chain.

The structures are called reserve pits. Mostly they contain drilling muds and cuttings. Muds are basically clay mixed with chemicals. They are used to control pressure in wells, preventing blowouts and making drilling easier. Cuttings are chips of rock.

But sometimes the pits also contain crude oil, water produced along with the crude, rig wastewater and contaminated snow

Tests of the pits show a wide range of contaminants, including arsenic, cadmium, chromium, lead, benzene, toluene, napthalene and paraformaldehyde. While these can be highly toxic in large concentrations, environmental officials say the biggest problem is salt, which is present in high levels and kills plants.

The contents of many pits have accidentally leaked through the gravel walls or spilled over the top in summer as accumulated snow melts. In 1985, the contents of one pit poured through a breach in a dike into a nearby lake used for drinking water.

Steve Taylor, head of the environmental division of Standard Alaska Production Co., acknowledges that reserve pit construction has not been adequate to prevent leaking. He said new state regulations requiring stricter control over the pits will force North Slope operators to improve or close many pits. Standard is looking for ways to insert impermeable liners into the walls of the pits.

Oil companies are allowed to reduce the contents of the pits in several ways. Some used muds are pumped back into nearby wells through "annular injection," a process by which muds are pumped into the part of the well that doesn't carry oil. In 1986, more

See Page A-9, PRUDHOE

Anchorage Daily News photos/Jim Lavrakas

DEC investigator Rich Cormack takes photos of dumped construction debris at a pad leased by Child's Equipment Services, a company that has filed for protection under bankruptcy laws.

DEADHORSE: Prudhoe Bay staging area gives the oil industry black eye

Continued from Page A-1

scrap metal, old wood, tires and other junk, came from a variety of sources. DEC talked to a number of companies that had once used the pad, but no one would accept responsibility, said Rich Cormack, a DEC field officer on the North Slope.

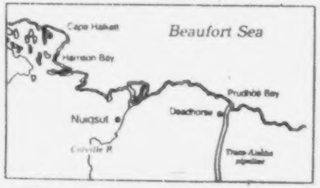
When officials contacted Child's, which had leased the gravel pad from the state, they found the company in Bankruptcy Court and unable to pay for the cleanup, he said.

The state has a $25,000 certificate of deposit posted by Child's when the company leased the tract, but Jerry Brossia of the state Department of Natural Resources said it is rare for the state to actually draw against such bonds. In fact, he said, in the five years he has been with DNR, the state has not cashed a single leaseholder's bond to pay for a problem.

Even if the money were claimed, Brossia said, it would go to the state's general fund and would need legislative approval before it could be earmarked for cleanup of the Child's pad.

So, it looks like the state of Alaska will foot the bill. Cormack estimated it will cost $20,000 initially, just to stop the leaking and do the first phase of cleanup. DEC already has put containment booms around the site and shoveled out an area of the pad to slow runoff onto the tundra.

Deadhorse is a more difficult environmental problem than the oil fields themselves. The major oil companies, which operate the fields, keep a tight rein on contractors working in them, but Deadhorse is a patchwork of gravel pads leased in the mid-1970s by the state.



Individual leaseholders hauled in gravel — much of it purchased from the state — and built their own pads along a road that runs from the airport to the oil fields. The pads are three to 60 acres, with troughs between them. Various lease stipulations and restrictions are aimed at keeping the pads clean and orderly, Brossia said.

DNR and other regulatory agencies conduct annual inspections to make sure companies comply with the rules. This year, mindful of the economic slump, DNR is stepping up inspections and trying to work with companies that might otherwise walk away, Brossia said.

"About three out of four pads are disgusting for one reason or another," Cormack said.

On a day in early June, just around the corner from the Child's pad, water drained from large mounds of oily snow on a pad leased by Kodiak Oil Field Haulers. The water flowed down one trough and toward the Saganavirktok River.

It happens year after year, said Brad Fristoe, who heads DEC's North Slope office, because the company cleans its oily trucks outside and just pushes the contaminated snow to one side. The company should have an indoor shop so the oily waste could be contained, drummed up and sent to a waste facility, he said.

But all that involves considerable expense, Fristoe said, so the oil flows to the tundra again and again.

Jim Taylor, president of Kodiak Oil Field Haulers, declined to discuss the waste problem, except to say it has been resolved.

DEC hasn't taken legal action against the company, Fristoe said, because it costs too much money and manpower to prosecute such cases.

"The department's philosophy is to work with the companies rather than take them to court," Fristoe said.

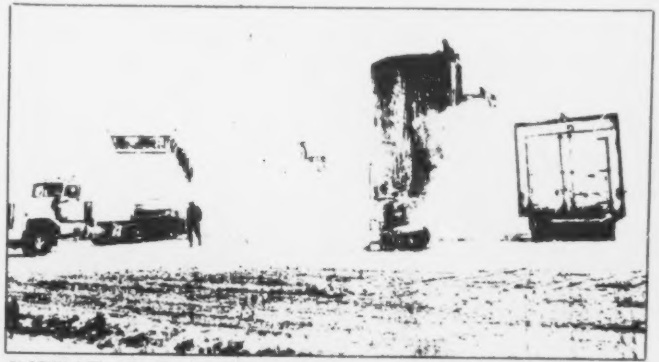
For example, he said, several years ago DEC spent 300 man-hours putting together a case against a North Slope salvage company that had dumped 15,000 drums on the tundra just off one of the pads. The case took years to move through the courts. The defendants were convicted on criminal charges and ordered to perform community service, rather than to pay fines or go to jail.

In the end, the major oil companies that originally owned the barrels of waste spent more than $1 million to complete the cleanup the salvage company had been paid to perform.

DEC and oil industry officials agree that a Deadhorse-type staging center must not be allowed to happen again, especially in an area like ANWR.

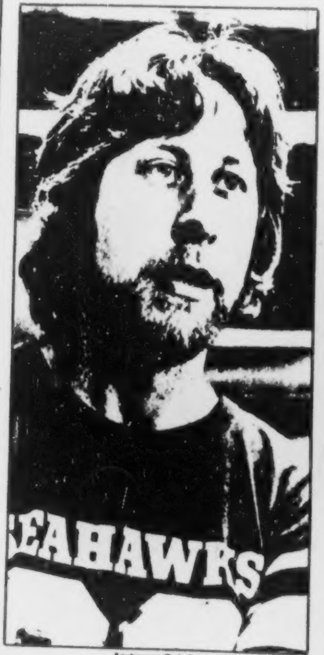
About six years ago, when ARCO Alaska Inc. developed its Kuparuk River field to the west of Prudhoe Bay, the service area was designed much differently. Called the Kuparuk Industrial Center, it has a single large gravel pad, with a central housing facility shared by all companies. Service companies lease shop space from the borough.

"Everybody is evolving and learning as we go along," said Ben Odom, senior vice president of operations for ARCO. "Each time we do it better. You won't see another Deadhorse the next place we go."



At ARCO drilling site #6, a large vessel is steam cleaned while waste water runs off the pad.

Anchorage Daily News Sunday, July 19, 1987 A9



Anchorage Daily News photos/Jim Lavrakas

DEC's Brad Fristoe: ". . . The long-term effects haven't really been determined."

Brad Fristoe smells the contents of an open drum that was illegally left at a pad leased by Child's Equipment Services in Deadhorse.

Continued from Page A-8

than 116 million gallons were injected into 171 wells.

Fristoe, the DEC environmental engineer, said annular injection seems to be a safe way to dispose of wastes because they are deposited deep in the ground, well below the permafrost, which acts as a barrier to keep them from surfacing.

Because snow melt causes pits to overflow, DEC also allows oil companies to pump millions of gallons of watery waste directly onto the tundra, or spray it on gravel roads for dust control. In 1986, according to state figures, about 37 million gallons of reserve pit fluids were sprayed on roads, and 65 million gallons discharged onto the tundra.

There are often more pollutants in the water than allowed, however, so DEC is trying to require more thorough testing of the water before discharge. In 1986, about half the discharges showed excessive levels of some contaminants.

"The quality of water that's going out probably is improving but the volumes aren't going down," Fristoe said.

Bob Adler, executive director of the environmental law firm Trustees for Alaska, worries that DEC allows vast amounts of pollutants to be discharged without knowing what effect it has. He cites a U.S. Fish & Wildlife Service study that found higher levels of hydrocarbons and heavy metals in areas where tundra discharge had occurred. Adler said the study shows that pollutants are increasing and spreading.

Taylor, however, is highly critical of that study. It's biased, relies on outdated practices and misinterprets the data, he said. Standard fears that faulty information will cause other federal agencies to require sweeping change in the handling of drilling wastes, he said.

Robin West, one of two Fish and Wildlife scientists who prepared the study, said the report did find high levels of pollutants in areas of tundra discharges, but "a lot of things we were looking at don't occur anymore."

West noted, however, that the study, done in 1983, did not try to predict long-term effects. No follow-up testing was done.

AIR QUALITY

Last summer, a visiting environmentalist set oil company officials on edge when he publicly suggested that Prudhoe Bay air pollution exceeded that of Chicago.

This year, industry scientists are circulating a report that says oil field air quality is much better than required by the U.S. Environmental Protection Agency. On the cover: A prominent graph showing Prudhoe Bay emissions considerably lower than not only Chicago, but New York, Los Angeles, Washington, D.C., and Lake Tahoe.

State and federal environmental officials say, however, that air quality may yet prove to be a problem at Prudhoe Bay, and perhaps of even greater concern at ANWR.

Al Ewing, head of the EPA in Alaska, said current North Slope operations meet existing law. "But there may be some problems in the future," he said, as EPA implements stricter air quality standards designed to prevent areas with good air from getting worse.

The most worrisome pollutants emitted by North Slope production facilities are nitrogen oxides, or NOx, which have been shown to cause acid rain in the northeastern United States. Most emissions on the Slope come from the giant natural-gas-fired turbines that power the production facilities.

Emissions monitoring was done early in Prudhoe Bay development, during 1979-80, and began again last year. Computers predicted where NOx pollution likely would be greatest, and monitoring stations have been set up in those areas. So far, testing shows emissions well within current federal air quality standards.

Jim Ives, an air quality specialist with ARCO Alaska, said data show emissions at the company's Kuparuk River field to be less than 17 percent of allowable levels and at Prudhoe Bay to be about 13 percent.

“*There's the potential for ma*
development, and that conce

"We're not having a significant impact," he said. Natural gas is "the cleanest possible fuel."

But new "increments" in the standards may make it harder for the companies to comply with federal law. The increments — which have not been set yet but will be designed to prevent deterioration of current air quality — will reduce the allowable emissions, Ewing said.

Moreover, expansion of the fields might be affected because companies would not be allowed to add facilities if doing so would boost cumulative pollution above the ceiling set for the area, he said.

NOx emissions are troubling for another reason. Some days, state environmental officials say, a yellow smog hangs in the air high above the oil fields. They believe it may be caused by NOx accumulation.

"That's something we at DEC are concerned about and feel needs to be looked at a little bit more," said Fristoe of DEC. "There may be a potential for acid rain, but nothing has been proved."

"There's no acid rain on the Slope," countered Standard Alaska's Taylor. "Nor would you expect any" because the climate of the Arctic prevents its formation.

Environmental groups point to the black smoke frequently spewed from North Slope facilities as a potential air quality problem that no one has addressed. The smoke occurs when natural gas produced with the crude is burned off, usually when a field is brought into production.

During a visit early this June, however, black smoke was routinely present as flare after flare burned across the horizon.

"What's in it?" asked Bob Adler of Trustees for Alaska. "What's the composition? How do you know what the health effects are? We have a right to know the answers before we act."

OIL SPILLS

Last year, according to state records, about 500 oil spills occurred at North Slope oil fields. Tens of thousands of gallons of petroleum products and crude oil flowed from open valves, damaged drums and ruptured lines.

Most of the oil spills on the Slope take place on gravel, either on roads or pads, state officials say. Very little of it reaches the tundra, where oil could kill plants or poison sensitive wildlife habitats.

No wells have blown out and no major pipelines have ruptured.

Still, environmental officials and conservation groups are concerned that a lot of small spills cumulatively could cause long-term problems, especially if the oil isn't cleaned up properly and eventually seeps through the gravel.

"Even though you don't see gross contamination, you know there's chronic stress going on," said Rich Cormack, a DEC official who specializes in oil spills.

Cormack said most of the concern over cumulative effects is in the Deadhorse area, where oil field service companies operate from dozens of individual gravel pads.

But major spills have occurred in the oil fields operated by ARCO and Standard, too. For instance, Cormack said, a pinhole leak in a pipeline a couple years ago spilled about

“*We're not having a signific*
cleanest possible fuel.”

Jim Ives, an air quality sp

sive and extensive
's us a lot.”

Ray Cameron, a state caribou biologist

10,000 gallons onto the tundra before it was stopped.

Large spills of thousands of gallons occurred routinely for years at one ARCO plant because of inadequate crude oil storage, Cormack said. DEC pointed out the problems to ARCO four years ago, he said, and the facility was upgraded last year.

ARCO spokeswoman Veronica Dent acknowledged that a couple of large spills occurred every year at the facility. But, she noted, the plant is one of the oldest facilities at Prudhoe Bay, and the spills were all in contained areas and therefore had no effect on the environment.

"Yes, there are a lot (of small spills)," said Taylor of Standard Alaska. "But when you put that in perspective to the size of the field," the spills are insignificant.

EFFECTS OF EXPANSION

Some biologists who watch over the Arctic's animals, birds and fish worry that someday oil facilities will stretch for hundreds of miles along the northern coast. Already, they say, there are indications that widespread industrial build-up could seriously disrupt species that would naturally use broad areas of the arctic slope.

So far, the two principal concerns are that caribou might be forced from their summer range and calving grounds by oil facilities, and fish could be blocked from free movement along the coast by a series of docks and causeways to offshore drilling islands.

Additionally, fish and game biologists are trying to keep a close eye on development within existing fields to ensure that wildlife is disrupted as little as possible.

"There's the potential for massive and extensive development, and that concerns us a lot," said Ray Cameron, a state caribou biologist who for 14 years has studied the central arctic caribou herd that roams the Kuparuk River area.

Other scientists, including many who work for oil companies, believe oil development, no matter how spread out, only affects a small percentage of a vast wilderness, leaving more than enough room for caribou and other animals. "It's almost insignificant," said Taylor of Standard Alaska.

But Cameron and other state biologists who have studied existing facilities say the caribou generally have been pushed off traditional habitat as oil field activity has increased.

Years ago, caribou moved through what is now the Prudhoe Bay field to the east of Kuparuk. But Cameron and others surmise that too many facilities too close together troubled the animals, and they no longer use the area.

At the newer Kuparuk field, large groups of caribou still wander by drilling rigs and production facilities, but state biologists believe they are beginning to see less use of the field by the central arctic herd.

Caribou use the North Slope area in summer to fatten up for winter. If they are bothered too much, whether by trucks or people or insects, they might not store up enough energy to survive the winter.

That's why some biologists are uneasy with the thought of widespread development. They wonder how far the caribou can be pushed before herds begin to die off.

"There's no question that there have been changes (in habitat)," Cameron said. "But the significance of the changes is unknown."

Others disagree that development is having a major effect on fish and wildlife. As proof, they point to the same Central Arctic herd, which has actually tripled in size in the last few years.

Anne Brown, an environmental scientist with Standard Alaska, said caribou populations throughout the circumpolar area have increased since the early 1970s because large numbers of wolves have been killed by trappers and hunters. Oil development has done nothing to discourage the herd's growth, she said.

Brown said she still sees lots of caribou in the oil fields, moving under pipelines and over them on special ramps. "It's impressive," she said. "I don't think there's any change that's been documented."

Environmental officials also are concerned that docks and causeways may block the migration of fish to Canadian waters, where residents rely on them for subsistence. Al Ewing of the EPA says the issue is one of the agency's top three priorities for the Slope.

North Slope causeways are made of gravel, with openings for fish to pass through. Ewing and state fisheries biologists say the causeways are definitely affecting the nearshore environment, changing water temperature and salinity, and possibly causing fish to avoid the areas.

The changes have been documented, Ewing said, but it remains to be determined what, if any, harm has been caused.

In onshore areas, fish biologists are concerned that the patchwork of gravel pads — about 13 square miles in all — has changed the flow of surface water. They want oil companies to correct problems with faulty culverts that block drainages and fish passage. Each year, culverts are replaced when spring floods wash out oil field roads, twisting culverts out of position and carrying large amounts of gravel into rivers and streams.

"I think the basic problem is they're trying to get away with culverts when they should be putting bridges in," said Dick Shideler, who oversees permits for the Department of Fish and Game's habitat division.

Oil companies, he said, feel that the cost of a bridge, generally in the millions of dollars, is too great. But Shideler said a bridge is actually more cost-effective over the life of the field because many of the culverts have had to be reworked year after year.

□

It's not hard to imagine that one day Alaska's North Slope will be a tapestry of oil production facilities, woven together by a network of roads and pipelines and pump stations. The entire northern region — from the National Petroleum Reserve in the west to the Arctic National Wildlife Refuge in the east — has long been eyed by oil developers.

A lot has been learned about arctic oil development in the 43 years since the U.S. Navy first searched the northern coast for an oil supply for a nation still at war. The evolution of Prudhoe Bay and other North Slope oil fields certainly has given environmental officials confidence in the industry's ability to operate with minimal effect on the environment.

Still, government biologists say more studies aimed at determining the long-term effects are necessary before they can feel truly comfortable about development of the next oil frontier — ANWR.

But time is running out. Advocates for both sides of the debate want Congress to decide soon.

Says one state biologist: "Pro-development interests are capitalizing on our scientific ignorance. They're putting the burden (to prove harm) on those of us who still have questions and are willing to admit we don't have the answers."

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cialist with ARCO Alaska, on air quality

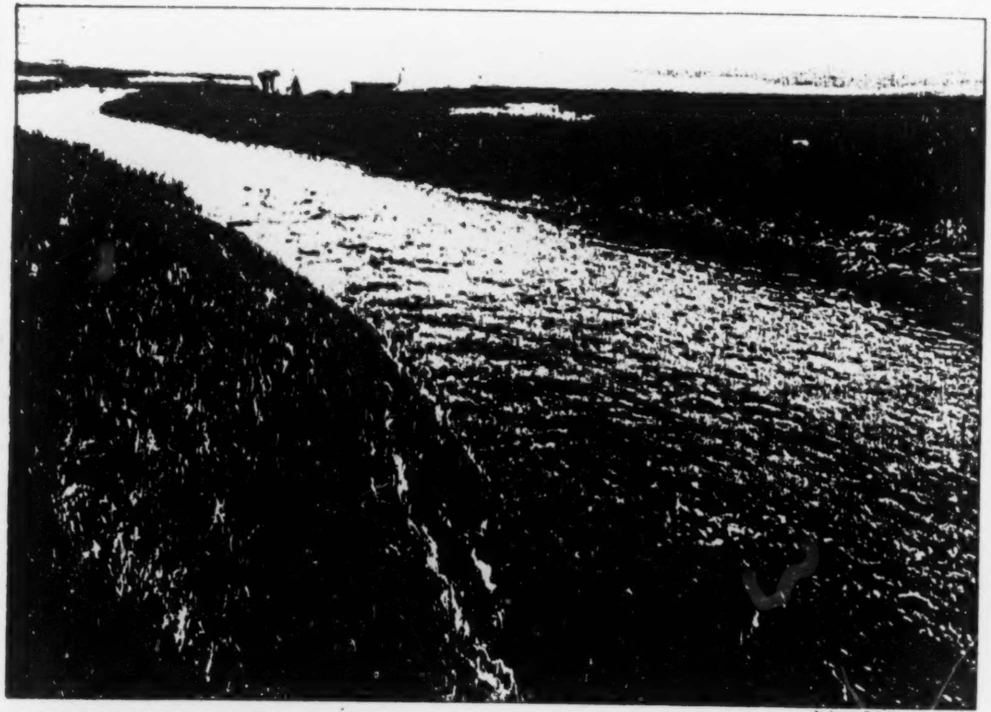
□ **MONDAY: Twenty years of pumping arctic oil has brought many technological advances.**

Lessons learned

Oil industry officials say arctic experience being put to good use

By PATTI EPLER
Daily News reporter

Last of a series



Anchorage Daily News/Jim Lavrakas

A U.S. Fish and Wildlife Service vegetation study crew sets up camp on Igilatvik Creek on the coastal plain 40 miles south of Kaktovik.

In 1944, the U.S. Navy and a team of federal scientists spudded the first oil wells on Alaska's North Slope.

They used steam-powered drilling rigs hauled in on "cat trains" — convoys of heavy equipment loaded on trailers and pulled hundreds of miles by giant Caterpillar tracked vehicles. The scars of their passage still streak the tundra.

Today, computers guide turbo drills miles into the earth with a precision that allows dozens of divergent wells to be drilled just a few paces apart. Pre-fabricated modules as big as 10-story buildings house sophisticated oil-production centers. Drilling pads and access roads are made of ice and disappear in summer, leaving no mark of a busy winter construction season.

Oil development on the Alaska frontier has come a long way. Now, the industry is being examined from all angles, pinned like a bug under the microscope that's being focused on Prudhoe Bay.

Many people, including members of Congress, want to know if oil companies can explore for and produce oil in a sensitive

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ANCHORAGE DAILY NEWS JULY 20th 1987

EXPERIENCE: Oil industry officials say lessons have been learned from work in Arctic

Continued from Page A-1

environment without causing serious damage. The issue is central to the question of whether Congress should let the industry look for new, potentially giant reserves in the coastal plain of the Arctic National Wildlife Refuge.

"For the past 20 years . . . we have led the world in the understanding and implementation of onshore technology in the arctic environment," Standard Alaska Production Co. exploration manager Roger Herrera told a House subcommittee last month.

State and federal environmental officials are less-than-ardent supporters of ANWR development, but they believe it can be done with minimal harm to the arctic ecosystem. Although Gov. Steve Cowper has asked Congress to approve leasing in most of the coastal plain, environmental officials have several concerns about oil-industry practices. They include how millions of gallons of oily wastes are disposed, and whether widespread development is changing the northern coastal region.

Conservation groups are voicing even graver worries, not only about the oil industry but about how good a job state and federal watchdog agencies are doing.

Industry officials dismiss the concerns. They argue that thousands of scientific studies have failed to document any serious environmental degradation.

Moreover, a myriad of technological advances have allowed companies to compact their operations so that much less tundra is disturbed. And, they say, even if Congress authorized ANWR development tomorrow, it would be at least 10 years before oil production could begin, giving industry scientists even more time to research and develop safer methods.

The learning curve has been a long one, and even oil companies admit they have made environmental mistakes.

But 20 years and five fields after the biggest oil strike in the history of America, the Alaska oil industry is deeply confident that ANWR's birds and animals will hardly notice them.

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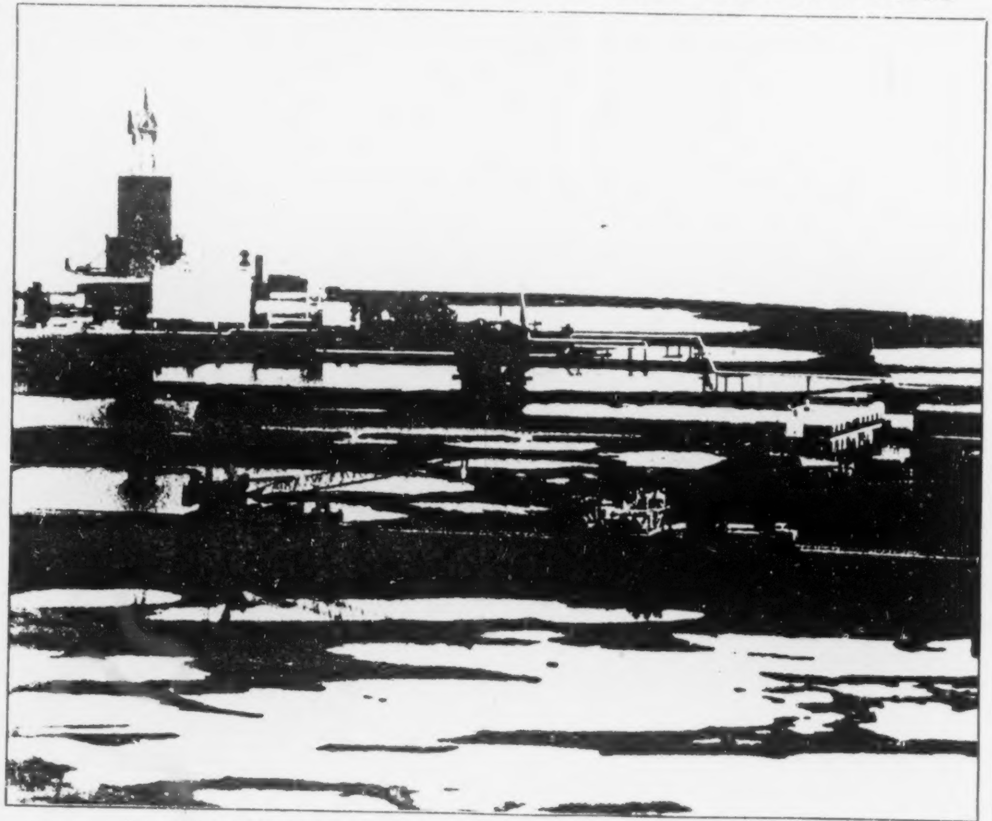
In the beginning, there was Prudhoe Bay. The largest oil field in North America has produced 1.5 million barrels of oil nearly



Anchorage Daily News file photo/Erik Hill produced 1.5 million barrels of oil nearly every day for 10 years. It now accounts for about 20 percent of U.S. oil production.

In 1965, the state sold its first North Slope leases, collecting $6.1 million from the sale of 297 tracts. Three years later, after 10 dry holes, Atlantic Richfield Co. punched through to a supergiant crude-oil reservoir, arguably the most important event in Alaska history.

The rush was clearly on. In 1969, oil companies paid $900 million for the right to drill at Prudhoe Bay.

The field began producing oil in 1977. Since then, three others — Kuparuk River, Milne Point and Lisburne — have been brought on line. Later this year, Endicott, the first offshore field on the U.S. side of the Beaufort Sea, will begin producing about 100,000 barrels of oil a day.

The Prudhoe Bay field has tripled in size since the June day 10 years ago that George N. Nelson, now president of Standard Alaska Production Co., stepped off a plane at Deadhorse to oversee Prudhoe operations.

Back then, he said, the industry's initial $200 million investment had bought it a single electrical power plant, one central compression plant to re-inject natural gas into the ground, and six facilities called flow stations or gathering centers to separate water and gas from the crude oil.

In the last decade, oil companies have pumped billions of dollars into Prudhoe Bay. Hundreds of production and work-over wells have been drilled, gathering centers and flow stations have been added and miles of roads and pipelines constructed as the companies continued to suck oil from throughout the reservoir.

ARCO Alaska Inc. brought Kuparuk into production in 1981, extending the network of roads, drill pads and pipelines further to the west.

Kuparuk development helped make Milne Point economically feasible for Conoco Inc. in 1985, and the road and pipeline complex branched north, stopping just short of the coast. The smallest of the North Slope fields, Milne Point was shut down last year when oil prices took a nose dive and has not been re-started.

ARCO filled in more of the North Slope tundra last year with the addition of Lisburne. That field lies generally along the coastline between Prudhoe Bay and Milne Point.

State officials estimate some 8,000 acres of gravel — about 13 square miles — are spread on top of North Slope wetlands in a gridwork of drilling sites, roads and support facilities.

Much of the evolution of northern oil-field development has been aimed at reducing this "footprint" that's been left on the tundra.

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Industry officials say the greatest advances have been made in drilling technology. "Now we're more sophisticated from an operations standpoint," said Nelson. "We need less surface area and less people so there's less impact."

Today's drilling rigs are more compact and mobile than those used in the early days of Prudhoe Bay, when Lower 48 rigs were hauled to the Slope.

As more wells were drilled, Alaska drilling companies began to adapt rigs for the arctic environment, which was proving a costly place to do business. Chief among the changes was the ability to drill wells closer together, and thus reduce the size of gravel drilling pads and the potential harm to the ecosystem.

Computerization and more sophisticated drilling equipment have fostered more precise drilling. Standard's Herrera said early Prudhoe wells were drilled 130 feet apart on a pad, and gravel pads were more than 2,000 feet long and 50 acres in area. As many as 48 wells were drilled from each pad.

More recent Prudhoe wells are 35 feet apart on a pad, while in Kuparuk they are separated by 25 feet. At Endicott, where drilling is from gravel islands just offshore, specially designed rigs sink wells that are 10 feet apart, Nelson said.

"Experience gained in drilling allowed us to do higher-angle drilling," he said, "giving us more reach."

Standard has been using a technique called horizontal drilling. The technique is not new for shallow wells, Nelson said, but Prudhoe Bay oil lies 10,000 to 12,000 feet below the surface. Basically, a well is drilled at a slightly increasing angle until it reaches the formation. Then it curves horizontally into the area to be drained.

Because of directional drilling ability gravel drill sites built by ARCO at Kuparuk are less than a quarter the size of earl Prudhoe Bay pads, said Jim Weeks, ARCO' Prudhoe field manager who oversaw Kupa ruk operations until recently.

"I guess the technology has evolved at th Slope from Day 1," Weeks said. "When w went to Prudhoe Bay we didn't really have great deal of knowledge of operating in th Arctic."

Advances in drilling technology are helping solve one of the major environmenta problems on the North Slope — potentia contamination from the massive amounts o toxic wastes that are produced when a well i drilled.

Now, the wastes are stored in huge grave pits, called reserve pits, adjacent to the dril site. The pits contain drilling muds an cuttings, but also often hold crude oil, contaminated materials from oil spills and othe oil-field wastes. Tests have shown the presence of toxic pollutants like benzene, cadm um, chromium and arsenic, among others.

The state allows the controlled discharg of some reserve-pit water. Eventuall millions of gallons of water from the pits ar discharged to the tundra or onto roads. Mud are generally re-injected down the well onc the well is complete.

But frequently wastewater in the pits ha leaked through the gravel walls. Sometime it simply overflows when snow built up fro

Part of the central gas facility for ARCO's Prud

Anchorage Daily News/Jim Lavrakas

With a drilling pad in background, state DEC investigator Rich Cormack takes notes at a private work pad waste dump at Deadhorse.

Bay production plant on it way from the West Dock barges to its permanent location

ter melts in spring. State and federal ironmental officials are worried poison- wastes could be accumulating in the rounding tundra, damaging sensitive dlife habitat.

'Originally, Prudhoe Bay field reserve s . . . were thousands of feet long simply ause we did not have the technology to ce production wells closer than 130 feet," d Herrera.

But smaller gravel drill sites have resulted smaller reserve pits. As the pits get aller, there is less waste — especially the ublesome snow melt — to be disposed of.

By the time Milne Point was developed, noco officials were well aware of the blems with reserve pits, said Al Hastings, enior staff engineer for the company.

Conoco built Milne Point's pits into the ter of its drilling pads, rather than at the e, so the drilling wastes are surrounded by to 150 feet of gravel. Most North Slope s are bordered by 30-foot wide gravel rms.

Conoco also tried to prevent leaching by raying the inside of the pits with clay, hough, Hastings said, that liner is not permeable.

Drilling-mud systems, which are used to ep pressure on the well during drilling to event blowouts, also have changed through e years, according to Nelson and others. tentially harmful additives in the muds, ke diesel, no longer are used.

Now, muds are cleaned and reused; only out half as much mud is needed for each ell today as was used years ago, Herrera id.

Standard will be conducting research this mmer into closing out pits, said Steve ylor, an environmental scientist with the mpany. One pit will be divided into sec- ons, leaving part of it undisturbed while rt will be covered with gravel and revege- ted to determine the best way to restore e pits, he said.

New drilling methods have reduced the me and cost of drilling, too, said Nelson.

In the early days, it took 40 days and $3.5 illion to drill a well, he said. Now a well n be finished in 18 days at a cost of about .5 million.

That means the companies can more easily mplete important drilling programs then ut down for environmental reasons, for stance, if wildlife sensitive to human activ- y moves into the area, he said.

"Technology is evolving all the time," said en Odom, senior vice president for erations for ARCO, "not only how to roduce oil, but how to meet environmental ncerns."

* * *

Oil companies also have learned how to se the arctic climate to their advantage. In e old days, the industry thought it had to uild all facilities during the short summer nstruction season.

Tracked vehicles, like the old cat trains, ired down in the thawed surface layer of ndra. "The only solution," Herrera said, was to blade the surface layer off so that acks could grip on the underlying perma- ost. The result was a disaster and quickly onvinced everyone that the movement of quipment was easier in the winter time."

Now, much construction is done in winter rom roads and pads made of ice. Oil ompany officials say they prefer to work rom ice structures. Ice roads and pads are nore cost-effective, they said, and they melt n the spring, leaving little, if any, environ- nental mark.

Standard built the first offshore ice road a ouple of years ago to a project, Nelson said. And other oil companies, including Amoco Production Co. and Exxon Co. USA, have constructed ice drilling-islands just offshore.

> ***“When we had to rely on state funding, we didn't have enough money to have a presence here. Prudhoe Bay basically happened before any of us had a chance to get involved. At Kuparuk we made a few greater strides.”***
>
> — Dick Shideler, an Alaska Department of Fish and Game habitat biologist who helps represent the department on the North Slope.

The construction of pipelines also is easier in the winter, Nelson and others said, because support pilings can be set in the permafrost.

"You cannot build pipelines on the tundra in summer," said Nelson, "because you just tear the tundra all to hell."

Many technological advances on the North Slope have centered around protecting wildlife, principally the thousands of caribou that move through the fields to summer coastal range. Over the past 20 years, oil companies have directed millions of dollars at environmental concerns, including thousands of studies deemed necessary before they could obtain government permits.

In the mid-1970s, when the trans-Alaska pipeline was built, it was thought the pipeline would block caribou migration. So pipeline owners built 556 specially designed animal crossings.

Later, scientists discovered the combination of a pipeline, an adjacent road and traffic created a significant barrier to caribou, said Standard's Herrera.

"The situation was not a problem along the TAPS pipeline, but it was within the Prudhoe Bay field," he said.

If any of the three factors — road, pipeline or traffic — was removed, caribou would cross relatively freely, he said. So pipeline design and construction techniques were refined again.

Now, at fields like Kuparuk River and Milne Point, where the large Central Arctic herd passes through, pipelines have been elevated five feet off the ground to allow free migration. And roads are up to 1,000 feet away.

At Milne Point, where the road and pipeline bisect a caribou calving ground, Conoco spent about $80,000 on a study to help the company design the road, said Al Hastings. The study detailed caribou use of the area and identified places where road crossings should be built.

Three ramps were built at a cost of about $250,000 each. "But the caribou cross where they want to, and not necessarily at the ramps," he said. Now, Milne Point pipelines are five feet off the ground, he said.

Still, some biologists remain unconvinced that a few ramps and some raised pipelines will satisfy the sensitive arctic herds.

See Page A-7, **EXPERIENCE**

Anchorage Daily News/Jim Lavrakas

State Department of Environmental Conservation's North Slope field manager Brad Fristoe looks at a drilling mud pit at Standard Oil's "J" pad.

EXPERIENCE: Lessons learned on tundra

Continued from Page A-6

State biologists who have studied the Central Arctic herd say large groups of the animals still move through the Kuparuk and Milne Point fields. But, they say, it appears use of the areas is lessening. And they still don't know if displacement will cause any decline in the herd.

Oil-field development apparently has brought improvement to other habitat areas. One example cited by biologists is an old gravel pit that was flooded to create a water supply and overwintering area for fish.

"If they have a good plan," fisheries biologist Carl Hemming noted, "they could end up with something better than they started with."

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Some 15 years after North Slope development began, state and federal environmental agencies decided it was about time to open an office on the Slope.

Until 1983, oversight of the largest oil fields in North America took place largely from offices in Anchorage, Fairbanks and Seattle.

"It's hard to know all the reasons for the minimal attention," said Al Ewing, head of the U.S. Environmental Protection Agency in Alaska. "Let's just say the North Slope was a long ways away."

Four years ago, $100,000 from the federal government cut the distance. The state resource agencies agreed to monitor coastal-zone development for the federal government, and regular staffing of a North Slope office began.

"When we had to rely on state funding, we didn't have enough money to have a presence here," said Dick Shideler, an Alaska Department of Fish and Game habitat biologist, who with Hemming represents the department on the Slope.

"Prudhoe Bay basically happened before any of us had a chance to get involved," Shideler said. "At Kuparuk we made a few greater strides."

DEC, the agency with the most enforce-

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State and federal environmental officials acknowledge that oil-field development has taken an environmental turn for the better, particularly as everyone's experience in the Arctic grows.

Now, attention is turning to ANWR, 100 miles east of Prudhoe Bay. Industry officials and government agencies are giving much thought to further refinements for the coastal plain.

For instance, industry officials say, directional drilling techniques developed at Prudhoe Bay will allow companies to keep drilling equipment well away from critical areas. They say they will be able to "reach out" for the oil as they have done, for example, in the Beaufort Sea to avoid the environmentally unique Boulder Patch.

Much drilling likely will be from ice pads and construction from ice roads, as has been the case in recent North Slope development, oil companies say.

But regulatory officials insist that a careful eye be kept on ANWR development, correcting environmental problems as soon as they are apparent. Most agency officials suggested setting up a multiagency monitoring team that would include a broad range of scientists and regulators. Such a team helped guide trans-Alaska pipeline construction with good results, they said.

Disposal of oil-field wastes must be addressed early on, Fristoe and Ewing said. Both said they would like to see better control over oil-field service companies and how they handle their operations.

"We'd like a say in where the Deadhorse of ANWR is going to be, too," Fristoe said.

"More oversight," said Ewing. "I think that's critical."

"I'd like to see (oil companies) carry to the extreme the effort to minimize and consolidate facilities — make sure we're not building any more than we have to."

"I guess it can be done," shrugged Shideler, the fish and game biologist. "The question is what are you willing to give up."

"Some things you can't mitigate," he said. "You just can't have an oil field in areas where there are sensitive species."

Al Hastings, the Conoco engineer, disagrees with that one. He pointed out that Conoco has operated successfully in Lower 48 wildlife refuges, including near sensitive whooping crane areas.

North Slope development is a good case study for those who want to extrapolate development concerns to ANWR, he said, as long as the examination recognizes that Arctic oil-field development has evolved and become more sophisticated in the 20 years since Prudhoe Bay started.

"Prudhoe Bay is always held up as the example," he said. "But if you're going to look at Prudhoe closely then you should look at (the newer) Kuparuk or Milne Point or Endicott (fields) because there are a lot of differences."

Anchorage Daily News/Jim Lavrakas

Ray Cameron, state Fish and Game caribou biologist, flies his own Super Cub outfitted with antennae for tracking radio-collared animals.

Anchorage Daily News file photo/Erik Hill

Standard Alaska's George Nelson

on the Slope before [illegible]," said Brad Fristoe, an environmental engineer who manages the North Slope office. Now, DEC has four North Slope officers who spend about 200 days a year wandering the oil fields and the haul road.

Fristoe, Shideler and other regulatory officials are convinced their presence has made a dramatic difference in the way arctic oil fields are now being developed.

They point to the changes in the way drilling wastes are being handled, and a general cleaning up of North Slope operations as evidence that, if left to their own devices, oil companies might shortcut sound environmental practices.

"Things seem to work a lot better if they know someone is looking over their shoulder," said Shideler.

Oil company officials, however, are proud of their environmental records. They say it is the companies that often take the lead in addressing new environmental concerns.

For instance, said ARCO's Jim Weeks, his company initiated the so-called "gravel conferences" in which oil companies and agency representatives work together to plan new development projects.

It began with the construction of Kuparuk, Weeks said.

"We said, 'Here's the number of wells we think we need to drill in the next year and the number of drill sites and here's the general area.'

"We knew where we needed to drill, we knew where the bottom of the hole needed to be and where drilling needed to be, but we had a lot of flexibility in the location of surface facilities."

Agency officials identify potential problems with the plans, then the oil companies adjust. "We've actually moved drill sites to get away from a particular waterfowl environment," Week said. "To mitigate noise interference we've routed roads and pipelines around certain things."

Anchorage Daily News/Jim Lavrakas

DEC Investigators Rich Cormack, Bob Cannone and Keith Mueller ride in a helicopter for overflight recording of Prudhoe Bay operations.

APPENDIX

Arctic National Wildlife Refuge—Environmental Issues

ARCTIC NATIONAL WILDLIFE REFUGE

ENVIRONMENTAL ISSUES

SUBMITTAL FROM THE STANDARD OIL COMPANY TO THE

UNITED STATES SENATE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
SENATOR J. BENNETT JOHNSTON, CHAIRMAN

JULY 22, 1987

76-226 0 - 87 - 5

LEASING WITHIN THE ARCTIC NATIONAL WILDLIFE REFUGE

The need for future domestic energy supplies and the associated economic benefits for most U.S. citizens give urgency to the issue of leasing the 1002 area of the Arctic National Wildlife Refuge (ANWR) coastal plain. While Alaska currently supplies 20 percent of domestic oil supplies, the giant Prudhoe Bay oilfield faces imminent decline. The 1.8 million barrels of oil per day currently produced in Alaska will have dwindled to less than 500,000 barrels per day by the year 2000. The U.S. dependence on imports will continue to increase. It has been forecast that the U.S. will import as much as 70 percent of its crude oil by the year 2000. This would place the nation in an unquestionably vulnerable position.

While the energy and economic issues are most compelling, Congressional review and discussion of potential oil exploration and development in the 1002 area of ANWR will logically include an examination of the environmental record of the Prudhoe Bay oilfield about 75 miles west of ANWR. While that record is the responsibility of the individual operating companies, it ultimately reflects the commitment of industry to environmentally responsible development. The record of petroleum development in the Arctic since the Prudhoe Bay oilfield was established clearly demonstrates this commitment and shows that oil industry activity is compatible with healthy wildlife populations.

Potential adverse impacts to wildlife populations will be a concern wherever there is oil and gas development, and North Slope petroleum activities will continually be monitored. Data from Prudhoe Bay show, however, that caribou have increased in numbers and that the species diversity and nesting density of birds have not changed. In fact, with the exception of a growing caribou population, there is no evidence that oilfield activity on the coastal plain has produced any statistically detectable change in the size or regional distribution of any fish or wildlife population using the area at any time of the year. Mitigative features incorporated into the design and operation of the oilfield have meant that impacts are local and that air quality, water quality and wildlife populations are not adversely affected.

Petroleum development does not radically alter the arctic environment. Over 800 wells have been drilled on the North Slope from 35 drill sites producing over 5 billion barrels of oil. Yet surprisingly little habitat has actually been covered: less than 2 percent of the total area of the existing Prudhoe Bay, Kuparuk, Milne Point, Lisburne, and Endicott oilfields has been physically affected by development. In ANWR, according to the three-oilfield development scenario used by the Department of the Interior for impact assessment purposes, only 0.8 percent of the 1002 area would be affected by full leasing, including the 7,000 acres predicted to be modified by indirect effects.

The Prudhoe Bay operating record is evaluated from virtually every perspective in this submittal: air quality, waste handling procedures, oil spill statistics, and wildlife populations. The issues of gravel and water availability in ANWR are also addressed. Still, several notions are worth mentioning, because they have been raised repeatedly as part of the ANWR debate: "the fragile arctic", "the last undisturbed arctic ecosystem", and "unique habitat".

"The Fragile Arctic"

The main reason the idea of a "fragile Arctic" originated is probably the phenomenon of thermal erosion. This process occurs when the insulating surface mat of tundra vegetation is removed or damaged, leading to summer melting of the exposed ground. Vehicle tracks from the days when trucks and bulldozers were allowed to travel cross-country over the tundra can still be seen in places. This practice has been prohibited for many years. Today the well-established field of arctic engineering uses standard practices that govern engineering design and construction in the Arctic, and extensive thermal erosion rarely occurs.

The phrase is catchy, however, and has been popularized to create the notion that the Arctic is delicate and that wildlife inhabiting the region are living on the edge of survival. There is no biological evidence to support this view. Quite to the contrary, arctic vegetation and wildlife (polar bear, caribou, muskoxen, waterfowl, shorebirds, arctic fish, etc.) are physiologically adapted to conditions of extreme cold and short summers. Furthermore, wildlife populations that inhabit oilfield areas have thrived and show no significant differences from populations in undeveloped areas of the coastal plain.

A striking example of this is the steady growth of the Central Arctic Caribou Herd during the period of petroleum development at the Prudhoe Bay, Kuparuk, and Milne Point fields, all of which include portions of this herd's summer range. In July 1973, biologists estimated the Central Arctic Herd at about 3,000 animals. By 1976, the estimate was 4,000-6,000 animals. A 1986 survey indicated that the Central Arctic Herd had reached an estimated 17,838 animals. Thus, available evidence indicates that since oilfield development began at Prudhoe Bay, the Central Arctic Herd has probably increased by four or five times its estimated size in 1973.

Other studies show that productivity of waterfowl can be maintained at pre-development levels and may actually increase in areas of industrial development, especially where Common Eiders and probably Brant are involved. These and other examples demonstrate that arctic plants and animals are no more fragile than species in any other part of the world. With proper management and mitigation, wildlife of almost any species can thrive in the presence of human activity. However, when habitat is mistreated, it declines in productivity. This is as true for American farmland as for arctic tundra: both are resilient when treated appropriately, and fragile when treated poorly. The Arctic Coastal Plain is different from areas to which most Americans are accustomed and must be handled with techniques suited to those differences. But the Arctic is no more fragile than any other place on earth.

"Last Undisturbed Arctic Ecosystem"

The coastal plain of ANWR has been described as the "the last undisturbed arctic ecosystem". This description incorrectly assumes that the area has never received human use and impact. There have been three Defense Early Warning (DEW line) stations in the area, one of which is still active. Also, the village of Kaktovik has been relocated three times in recent history, with resulting disturbances. The ANWR coastal plain has a history of reindeer herding dating back to the introduction of reindeer to Alaska in the late 19th

Century. Human presence in ANWR has been light, but it has been there historically and continues today.

This concern also reflects the common misconception that oil and gas leasing in the 1002 area would lead to development of the entire ANWR coastal plain. When ANWR was established, a significant portion of the coastal plain was incorporated into the National Wilderness System and is not being considered for leasing. This forgotten coastal plain wilderness, approximately 450,000 acres with 30-plus miles of coastline, extends east of 1002 to the U.S.-Canada border. It is part of the refuge's 8 million acres of legally designated wilderness, and it adjoins Canada's 3 million acre Northern Yukon National Park. Together they provide a vast continuum of coastal plain wilderness that would be untouched by oil and gas activities in the 1002 area.

"Unique Habitat"

While no two areas of the earth are completely alike, there is nothing biologically "unique" about the 1002 area in relation to other parts of the Arctic Coastal Plain. It contains landforms and biological resources found on adjacent lands. The ANWR wilderness lands to the east and south of the 1002 area include abundant examples of all geologic, terrain, habitat, and wildlife features found in the 1002 area. The true uniqueness of the 1002 area is its petroleum potential.

Congressional Authorization of Leasing

Regional surface and geologic information confirm that ANWR is the most promising unexplored region in the U.S. for oil and gas. Nevertheless, the geology is unquestionably complex. If the area is to be rationally and thoroughly explored it will take not only the commitment of Congress, but the investment of tremendous financial resources, time, and human energy. Even with such a commitment, however, there are no guarantees. The Prudhoe Bay discovery was preceded by 10 dry holes, and the North Sea discovery by 28 dry holes. Without a vested interest, operators are unlikely to continue exploration if initial efforts are disappointing. Without the potential reward of future production, the economic risks are unacceptable. No company will be willing to commit the resources required to explore ANWR properly without a chance of recouping the associated costs. Just as wilderness legislation would abandon the wisdom of providing for the future by preventing oil exploration and environmentally safe development, exploration-only legislation would prevent a critical and thorough evaluation of the region's energy potential.

Foresight requires that leasing of the 1002 area be evaluated with respect to future energy requirements and be weighed against realistic assessments of environmental costs. ANWR holds the greatest potential for relief from the tremendous shortfall in domestic energy reserves our nation currently faces. With the 15-year lead time anticipated for future oil development in the Arctic, the decision to explore for oil should not be postponed. Given the care with which oil exploration and production can be conducted, the effectiveness of environmental safeguards incorporated into facility designs and oilfield operations, and the extensive regulatory controls now in place, we urge Congress to authorize full leasing of ANWR.

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WATER RESOURCES - SUMMARY

Water Availability

- Naturally occurring sources of fresh water can be limited in the 1002 area, but this is true throughout the North Slope.

- Methods by which water has been extracted include:

  (1) Deepening side channels and flood plains of river and stream beds;
  (2) Excavating deep pools in lakes;
  (3) Insulation of ponds to prevent freezing to bottom;
  (4) Desalination of sea water;
  (5) Erecting snow fences to trap snow and melting with snow melters;
  (6) Converting gravel extraction pits to water reservoirs.

- All of these options have been tried successfully for one or more of the 250 exploratory wells drilled in the arctic desert.

Water Requirements for an Exploratory Well

(1) 1.5 acre-feet of water per mile for construction of an ice road.
0.02 acre-feet of water per mile for daily road maintenance.

(2) 9.2 acre-feet of water for construction of a Hercules airstrip.
0.01 acre-feet of water for daily maintenance.
(Volume would be less if airstrip is built on a frozen lake.)

(3) 0.1 acre-feet of water daily for drilling rig and domestic use.

Question of Potential Impact on Fish Populations

- Standard practice includes the survey of rivers to locate deep holes sufficient to support overwintering fish, ensuring their protection.

- State Department of Natural Resource and local North Slope Borough permits are required for water use from rivers or lakes or ice road construction.

- State Department Fish and Game Title 16 permits are required for water withdrawal or ice road construction when the activity involves fish bearing streams. It is their policy not to issue permits for ice roads crossing fish overwintering sites.

- Permit conditions provide strict criteria for water removal techniques, extraction periods, discharge limitations, and water source restoration plans.

WATER RESOURCES

Water Availability

An issue frequently raised with regard to leasing in ANWR has been the availability of sufficient supplies of fresh water for petroleum operations. Those unfamiliar with arctic operations fear that the limited availability of fresh water in ANWR would result in a major depletion of regional water supplies to the detriment of fish and wildlife populations. Although it is correct that the availability of fresh water is limited, it should be understood that this is not a problem unique to the 1002 area, and it is one which has been successfully dealt with many times. Operators have numerous options eliminating the need to draw water from any area where its removal would affect the health of fish or wildlife populations. Over 250 exploration wells have been drilled in the North Slope arctic desert without adversely affecting fish or wildlife.

Methods developed to satisfy water requirements elsewhere in the Arctic will be applicable to activities in ANWR. Just as water availability varies by location, solutions to providing water will have to be considered on a site-by-site basis. Examples of methods that will be contemplated include creating deep pools in or adjacent to river/stream beds that will not freeze to bottom (thereby increasing fish overwintering habitat), creating deep pools in lakes, desalinating sea water, erecting snow fences to trap snow which could be used with snow melters, insulating lakes to keep them from freezing to bottom, and the converting gravel extraction pits to reservoirs. For isolated exploratory sites where there are no other reasonable alternatives, water can be backhauled from approved locations. Water availability will not limit industry's ability to operate in the region.

Fish Overwintering Habitat

It has long been recognized by industry and government biologists that overwintering areas for fish are limited in the Arctic. It is estimated that the freeze-up of large river systems reduces fish habitat by as much as 95%. Many areas not frozen to bottom are still marginal for fish overwintering. Their ability to support fish populations is a function of the number of fish overwintering in the deep pool, ice thickness, and duration of blockage of instream water flow by ice upstream -- all of which can vary annually. River surveys to locate deep holes are conducted before any operations that might affect overwintering fish are begun. It is standard practice to avoid both water removal and the construction of ice roads where the activity might adversely affect water availability and the survival of overwintering fish. Overwintering sites are routinely monitored to evaluate any unforeseen effects from a project.

Water Requirements

Water requirements for drilling in ANWR are the same as for other arctic drilling locations. The water requirements for drilling an exploratory well are approximately:

(1) 1.5 acre-feet of water per mile for construction of an ice road.
0.02 acre feet of water per mile for daily road maintenance.

(2) 9.2 acre-feet of water for construction of a Hercules airstrip.
0.01 acre-feet of water for daily maintenance.
(Volume would be less if airstrip is built on a frozen lake.)

(3) 0.1 acre-feet of water for drilling rig and domestic usage required daily.

Water for the above requirements could be obtained from any one or combination of alternative sources mentioned previously. For development operations, it is likely that most water required for drilling operations will be withdrawn from unused gravel extraction pits located in the deadarms of nearby rivers or from the desalination of seawater. Water withdrawn from gravel extraction pits during the winter would be quickly replenished during the subsequent spring snowmelt. Water availability should not be an issue with regard to leasing in ANWR.

GRAVEL RESOURCES - SUMMARY

Gravel Requirements

- Gravel is the most structurally and environmentally sound construction material for operations on the North Slope.
- Gravel provides the best insulation of the permafrost underlying the tundra.

Availability

- Gravel is naturally abundant throughout the 1002 area within 75 feet of the surface.
- There are many large areas of exposed gravel in active floodplains above the high water mark so that removal would not affect water quality.

MITIGATION OF VISUAL IMPACTS

- Upland sites can be restored successfully by contouring, placement of soil cover, and providing conditions for revegetation by native species. The application of fertilizers and light seeding has been demonstrated to speed this process.
- Upland sites were successfully rehabilitated in the National Petroleum Reserve-Alaska and along the Trans-Alaska Pipeline.
- Gravel extraction sites in active floodplains can easily be flooded and used as water sources while also increasing fish overwintering habitat.

MITIGATION OF HABITAT LOSS

- Gravel requirements are minimized by consolidating support facilities and by drilling multiple wells directionally from a single gravel pad.
- Gravel extraction sites can be flooded to create new water sources and to serve as additional fish overwintering habitat.

GRAVEL RESOURCES

Gravel Availability

Gravel is used to build drilling pads because it is the most structurally and environmentally sound construction material for operations on the North Slope. Gravel is also a natural material that is readily available in large quantities in the 1002 area. Drill logs and core samples obtained during recent geophysical surveys indicate that gravel deposits are more widespread in the 1002 area than at Prudhoe Bay, where they have been more than adequate to meet the needs of both onshore and nearshore petroleum exploration and development. Virtually the entire 1002 area is underlain with gravel less than 75 feet subsurface.

It is not surprising that this area of the North Slope harbors significant gravel resources. The Brooks Range mountains are at their closest to the Beaufort Sea in the ANWR region. The shorter, steeper-gradient streams and rivers flowing down from the Brooks Range have carried a significant load of gravel throughout their length and deposited it in large alluvial fans on the coastal plain. Large rivers such as the Sag or Colville do not intercept the north-moving drainage to deprive the coastal streams of discharge and gravel load. The basic geomorphological setting, and recent geotechnical data from the coastal plain, clearly show that there are available gravel resources. There are numerous options available to the operator. Actual decisions on the location and technique for gravel extraction will logically be made on a site-specific basis.

Concerns with respect to gravel extraction are twofold: (1) topographic changes and visual impacts, and (2) minimization of wetland loss or habitat modification due to gravel placement. It is possible to mitigate most concerns through careful siting of borrow pits and the consolidation of facilities. Industry has shown that gravel can be used without significant adverse impacts.

Gravel Extraction

There are many proven techniques to remove gravel from active floodplain gravel bars, river terraces, and upland (non-river) locations and to mitigate visual effects at upland sites by grading to contour, restoring soil cover, and providing conditions for recolonization by native vegetation. Evidence from studies of the Trans-Alaska Pipeline construction sites and recent drill sites in the National Petroleum Reserve-Alaska demonstrates that routine restoration procedures begin to be effective within the next growing season following gravel removal. As recognized in the Department of Interior (DOI) Final 1002 Report, many gravel sites can be converted to water reservoirs. These reservoirs may also provide fish overwintering habitat.

Gravel extraction locations will depend on site-specific evaluations of available options and quantities required. As emphasized in the Final 1002 Report, gravel should be removed from exposed sources wherever possible, particularly those above river ice in the streambed. Any final leasing action should clarify that gravel removal from river floodplains will be eligible for approval on a case-by-case basis. It should also be understood that all gravel activities are regulated through individual permit procedures.

Pad Construction

It has been industry practice at Prudhoe Bay, and elsewhere in the Arctic, to consolidate as many facilities as possible thereby minimizing surface impact and habitat loss through careful field design. Support facilities have been consolidated, for example, by having one power station provide electricity for both the Arco and Standard Oil operated areas. Directional drilling allows a large portion of the reservoir to be tapped from a single drilling location. This consolidation has limited the surface impact at Prudhoe Bay, the largest oilfield in North America, to about 2% of the 360 square miles of the operating area. With the evolution of drilling technology and production facility design, it is estimated by the DOI in the Final Legislative Environmental Impact Statement (FLEIS) that less than 1% of the surface of the 1002 area would be affected with the development of three large oilfields.

To further reduce gravel requirements, DOI recommends that foam and timbers be incorporated into gravel pads where feasible. Gravel remains the preferred material for drilling pad construction, however, because of its strength, stability, availability and ease of maintenance. Although it is possible to consider the use of foam and timbers on a case-by-case basis for exploration pads, the stability afforded by a solid gravel pad is needed for development and production facilities. The large supplies of gravel available in the 1002 area, coupled with proven extraction techniques which minimize impacts, support the use of solid gravel pads. In addition, as noted in the FLEIS, foam used in a gravel pad can break down and erode into smaller pieces that can be very difficult to effectively remove from the tundra. It would appear prudent to use a naturally occurring substance like gravel from the area rather than introduce a foreign material.

Gravel requirements will always be evaluated on a site-specific basis. Gravel removal and placement will be reviewed and evaluated through the extensive permitting process that precedes any exploration or production activity. Gravel extraction will also be evaluated as part of the Environmental Impact Statement process that preceeds any major development. Through the State Department of Natural Resources land use permit, State Department of Fish and Game Title 16 permit, Federal Fish and Wildlife Service or Bureau of Land Management special use permits, U.S. Army Corps of Engineers 404 permits, and the Coastal Zones Consistency Determination process, every state and federal resource agency will review all proposed actions and require changes to a project as they deem appropriate. Local gravel supplies are more than adequate to support major petroleum development and can be sensibly utilized without causing adverse environmental effects.

PRUDHOE BAY AIR QUALITY

AIR QUALITY STANDARDS

- National Ambient Air Quality Standards are not violated in the Prudhoe Bay Oilfield. Levels of air pollutants are well below those allowed by these standards.
- Prudhoe Bay ambient air quality is superior to that in large cities for all "criteria pollutants" (nitrogen oxides, ozone, carbon monoxide, sulfur dioxide, particulates, and lead).
- All equipment meets emission limits, and air monitoring programs demonstrate excellent air quality.

NITROGEN DIOXIDE

- Oxides of nitrogen are the primary emission from burning natural gas (other pollutants are minimal).
- Quantities of oxides of nitrogen emitted at Prudhoe are less than 25% of the amount allowed by permit and meet new source performance standards.
- Prudhoe Bay ambient level of nitrogen dioxide is consistently below 15% of the level allowed by the National Ambient Air Quality Standards.

SULFUR DIOXIDE, OZONE, CARBON MONOXIDE, PARTICULATES, LEAD

- Prudhoe Bay ambient levels are extremely low: no lead, almost no sulfur dioxide or ozone.
- Ambient levels of particulate can be elevated by naturally occurring wind blown dust. No violation of particulate levels have occurred.

ARCTIC HAZE

- Facilities on the North Slope do not contribute to arctic haze because they burns low-sulfur gas (arctic haze is mainly sulfur aerosols).
- Arctic haze may be due to long-range transport of pollutants from Eurasia.

ACID DEPOSITION

- Prudhoe Bay emissions are not a source of acid deposition on the Slope.
- Acid deposition from Prudhoe Bay facilities would be indicated by nitrates on the ground. North Slope levels are as low as those in Antarctica.

FLARES

- Flares burn natural gas and normally burn without smoke.
- Black smoke flaring events are short-lived and infrequent (less than 2 per month in the Western Operating Area).
- Carbon particulates from incomplete combustion are responsible for the black smoke (combustion still 95%-98% complete).
- Black smoke does not indicate an increase in other pollutants.

SUMMARY OF PRUDHOE BAY AMBIENT AIR QUALITY
(WESTERN OPERATING AREA DATA)

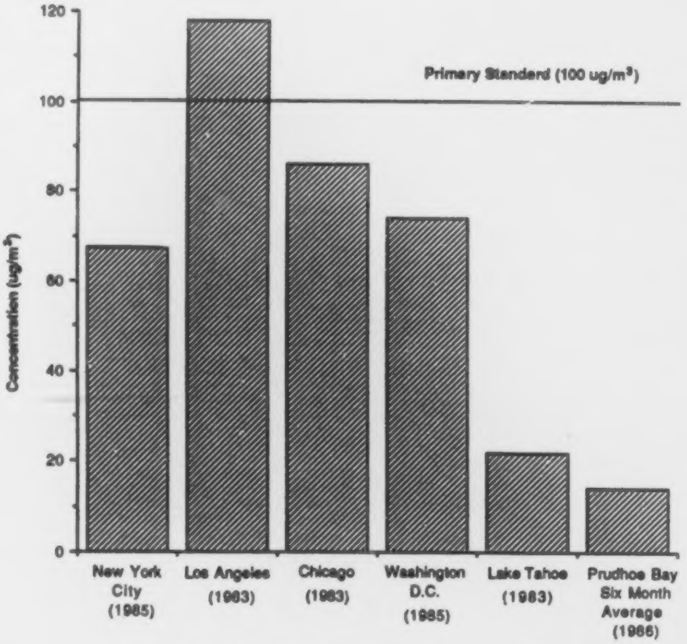
POLLUTANT	NATIONAL AMBIENT AIR QUALITY STANDARDS PRIMARY	SECONDARY	MAXIMUM LEVELS AT PRUDHOE (micrograms/cubic meter)
	(micrograms/cubic meter)		
Nitrogen Dioxide			
Annual Arith. Mean	100	100	14
Ozone			
1 Hour Maximum	235	235	92
Carbon Monoxide			
1 Hour Maximum	40,000	40,000	3,200
8 Hour Maximum	10,000	10,000	300
Sulfur Dioxide			
3 Hour Maximum		1,300	21
24 Hour Maximum	365		16
Annual Arith. Mean	80		Less than detectable limits
Total Suspended Particulates*			
24 Hour Maximum	260	150	24
Annual Geo. Mean	75	60	6

* EPA has proposed new regulations to monitor particulate matter under 10 microns in diameter in lieu of total suspended particulates. These are particulates of concern for health. Data from Kuparuk indicate very low concentrations of PM_{10} (less than 30 micrograms per cubic meter).

NOTE: Lead is not emitted from Prudhoe Bay facilities, and measurements of lead are not required for the Prudhoe Bay ambient air monitoring program.

OIL AND GAS DEVELOPMENT
IN THE
ARCTIC NATIONAL WILDLIFE REFUGE
1002 AREA

Air Quality Issues



Annual Ambient Nitrogen Dioxide Concentrations

AIR QUALITY ISSUES:
THE PRUDHOE BAY OILFIELD IN PERSPECTIVE

June, 1987

A White Paper Prepared By
THE STANDARD OIL COMPANY

6874V

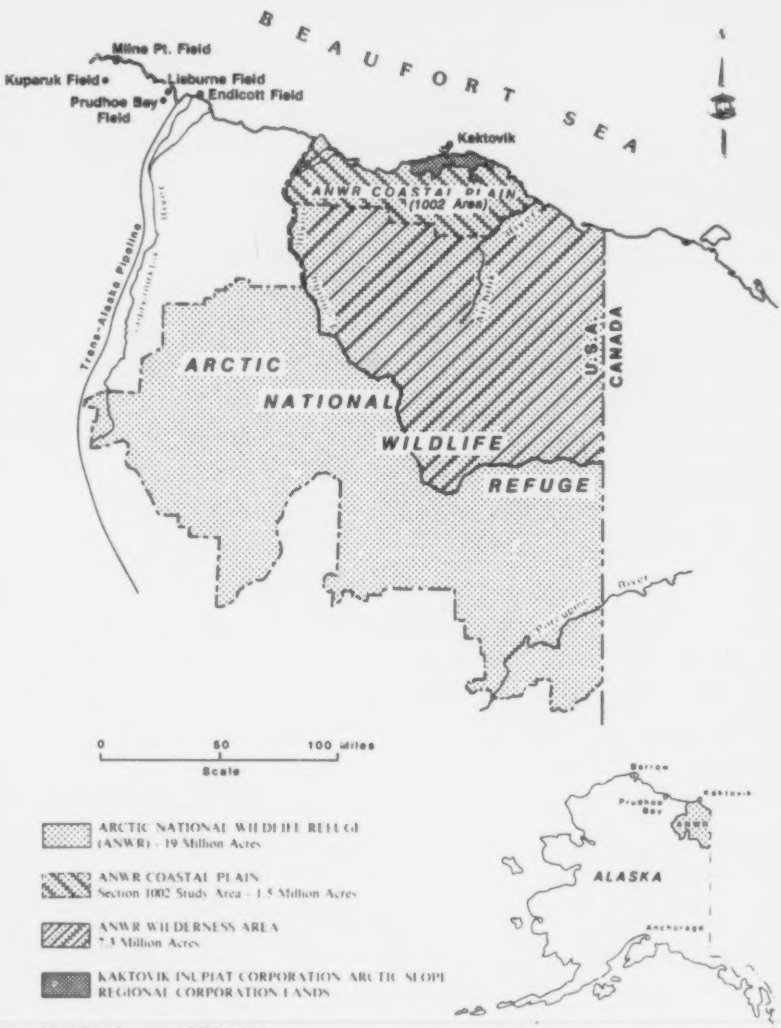
AIR QUALITY ISSUES:
THE PRUDHOE BAY OILFIELD IN PERSPECTIVE

The potential impact on air quality is one issue which has surfaced in the debate over whether or not the 1002 area of Alaska's Arctic National Wildlife Refuge (ANWR) should be opened to oil and gas development (Fig. 1). Opponents of the Secretary of Interior's recommendation to allow leasing of the 1002 area have alleged that the arctic air mass is now heavily polluted by emissions from operation of oil and gas production facilities at Prudhoe Bay. They have gone so far as to assert that the air in Prudhoe Bay is more polluted than in major industrial cities of the Lower 48 states. The fact is that air quality at Prudhoe Bay is consistently better than required by national standards and is substantially better than the air quality in large cities.

First of all, this paper examines the nature of the ambient air quality standards and the sources of air emissions at the Prudhoe Bay oilfield. Secondly, data is presented from air quality monitoring programs required by government permits and conducted under regulations developed by the U.S. Environmental Protection Agency (EPA). These data clearly demonstrate the excellent quality of the ambient air at Prudhoe Bay. Finally, this paper will briefly touch upon the issue of arctic haze and show that this problem is not related to oilfield operations on the North Slope.

Air Quality Standards

Congress laid down the basis for regulating air quality by the 1970 passage of the Clean Air Act, which established the National Ambient Air Quality Standards. These standards set safe levels for the ambient concentrations of six "criteria pollutants": carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, total suspended particulates, and lead. The levels represent the maximum concentrations of these criteria pollutants that are allowed in the air. Both primary and secondary


BEAUFORT SEA
Milne Pt. Field
Kuparuk Field
Lisburne Field
Endicott Field
Prudhoe Bay Field
Kaktovik
ANWR COASTAL PLAIN (1002 Area)
Trans-Alaska Pipeline
ARCTIC NATIONAL WILDLIFE REFUGE
U.S.A.
CANADA
Porcupine River
0
50
100 Miles
Scale
ARCTIC NATIONAL WILDLIFE REFUGE (ANWR) - 19 Million Acres
ANWR COASTAL PLAIN Section 1002 Study Area - 1.5 Million Acres
ANWR WILDERNESS AREA 7.3 Million Acres
KAKTOVIK INUPIAT CORPORATION ARCTIC SLOPE REGIONAL CORPORATION LANDS
Barrow
Prudhoe Bay
Kaktovik
ANWR
ALASKA
Anchorage

Modified from: ASRC 1986

FIGURE 1. ARCTIC NATIONAL WILDLIFE REFUGE

standards were set for these pollutants and are based on a number of different time frames for measuring ambient concentrations -- for example, 3 hours, 24 hours, one month, etc. The primary standards are designed to protect human health with an adequate margin of safety, while the secondary standards represent the levels necessary to protect the public welfare from adverse effects.

The 1977 Clean Air Act Amendments required that limits be established for allowable increases of ambient concentrations in those areas meeting the National Ambient Air Quality Standards. This provision is referred to as the "prevention of significant deterioration" (PSD). Congress mandated the establishment of "incremental limits" to insure that the air quality would not deteriorate in these "attainment areas." Thus, in an area that is relatively clean, these incremental limits would prevent concentrations in the area from ever reaching the maximums set by the ambient standards. The entire North Slope of Alaska, where the Prudhoe Bay field is located, is an attainment area and is subject to these incremental limits.

Since areas around the nation have different baseline air quality, these so-called "increments", when added to the baseline concentrations, established new standards more stringent than the National Ambient Air Quality Standards. For example, if the baseline level of particulates in an area is 11 micrograms per cubic meter and the allowable incremental increase is 37, particulate concentrations from all sources, including new ones, cannot exceed 48. This "incremental limit" is, in effect, the new standard for the area and is much more stringent than the national standard of 260 micrograms per cubic meter for particulates. To date, increments have only been established for particulates and sulfur dioxide.

The law also established three different regional classifications, each with its own allowable "increment." These classifications allow sufficient growth in heavily industrialized areas while minimizing industrial growth in undeveloped environments. Class I areas are "pristine" environments and have the lowest allowable increments. Only minimal increases are allowed in concentrations of particulates and sulfur dioxide compared to the baseline levels. New sources undergo stringent permitting requirements in the Class I areas. Areas designated as Class II have increments which allow for moderate growth but still ensure that air quality will be maintained. The entire North Slope, as well as most of the United States, has been designated Class II. Class III areas would be heavily industrialized and allow for significant growth.

Since the PSD regulations went into effect, both existing and new emission sources in attainment areas are required to use the "best available control technology" to minimize their emissions. New sources must also meet the set of national emission limits referred to as the "new source performance standards." These regulations set limits on the emissions from these sources, and in many cases the limits are the same for both new and old sources.

A new emission source is thus judged by the amount it will contribute to the levels of pollutants in the air in the source's locale. Before a permit can be obtained for operation of the source, analyses are completed of the local air quality and the emission control technology that will be used. The air quality analysis usually consists of (1) an examination of pre-construction ambient air monitoring data to determine existing air quality and (2) dispersion modeling to predict impacts from the new facilities. This air quality analysis must show that continuous operation of proposed emission sources, in conjunction with emissions from existing facilities, will not exceed the national standards. In addition, the allowable incremental limit for increases in ambient concentrations of total suspended particulates and sulfur dioxide must be met.

A technology analysis is also completed to examine the methods used to control emissions from the proposed source. Regulations stipulate that facilities must use the best available control technology, which considers environmental, energy, and economic impacts from proposed sources and sets the maximum permitted emissions from the equipment's exhaust stacks. In addition, these maximum permitted emissions must be at least as stringent as the new source performance standards. Following startup of a permitted facility, "stack tests" are performed to measure actual emissions from the source to determine compliance with the permit limits.

The meteorology, geography, fuel type, equipment type, and stack emission limits all play a role in the determination of the ambient air quality impacts from a facility. Therefore, it is the combination of the technology and air quality analyses that ensures that the minimal amount of emissions enter the atmosphere. This combination provides a method of predicting whether operation of proposed emission sources will meet the national standards. However, collection of air monitoring data after construction will verify the predicted levels and demonstrate whether the national standards are achieved.

Emissions from North Slope Oil and Gas Facilities

The primary sources of air emissions from North Slope oil and gas production facilities are natural-gas-fired turbines and heaters. This equipment is used to supply power to produce and transport crude oil and natural gas; to separate gas, oil, and water; and to inject gas and water into the reservoir.

The principal emissions from natural-gas-fired turbines are nitrogen oxides. Emissions of the other criteria pollutants from North Slope turbines and heaters are minimal because natural gas is one of the cleanest fuels available. Emissions of particulates from natural-gas-fired operations are negligible. Because the hydrogen sulfide content of North Slope natural gas is very low (averaging only 10 to 15 parts per million), sulfur dioxide emissions are minimal. Since the natural gas is lead free, lead emissions are of no concern. The complete oxidation of the carbon in the fuel results in quite low concentrations of carbon monoxide in turbine exhaust gas -- on the order of 10 parts per million or less (Davidson and Gullett 1987). Hydrocarbon emissions, the precursors to the formation of ozone, are also minimal due to this complete combustion.

A minor, though visible, source of emissions on the North Slope is the flare systems associated with the oil processing facilities. These natural gas flares are part of the safety system necessary in oil and gas facilities. Normally, excess gas from facility upsets is diverted to a smokeless flare. Occasionally, however, very large pressures must be immediately relieved by diverting large volumes of gas to a secondary burning system that generates smoke. These events are short-lived and infrequent. Although the black smoke is very visible, combustion is still about 95% complete, and there is no real contribution of criteria pollutants. The only effect is the temporary visual impact.

Determining Air Compliance

Facilities on the North Slope are subject to the emission limitations discussed earlier, and two methods of monitoring are carried out to determine compliance with the permitted emissions limits and the national standards. Equipment is stack-tested to determine actual emissions, and air monitoring is conducted to determine the effect of these emissions on air quality.

Stack Testing. Stack testing is routine for new equipment and must follow testing procedures mandated by the EPA. Each type of turbine or heater is tested on the North Slope by a third-party independent contractor soon after the equipment is placed in operation. In the more recent stack tests, a representative of the Alaska Department of Environmental Conservation (ADEC) is usually present to monitor this testing procedure. These stack tests verify that the emission limits for criteria pollutants of concern are met.

The gas-fired turbines, most of which are in the 30,000-35,000 horsepower range, produce most of the nitrogen oxide emissions. The permits obtained for operation of North Slope facilities require that any single gas-fired turbine emit less than 150 parts per million nitrogen dioxide. The procedures to be followed for carrying out these compliance tests are outlined in EPA regulations contained in Title 40 of the Code of Federal Regulations (40 CFR 60). North Slope equipment consistently meets permit requirements for nitrogen dioxide emissions and generally produces emissions well below the mandated limits (Table 1).

TABLE 1

COMPARISON OF MEASURED TURBINE EMISSION LEVELS TO MAXIMUM ALLOWABLE RATES (PRUDHOE BAY, ALASKA)

NOTE: All measured emissions are below allowable rates

TURBINE	CAPACITY (horsepower)	ALLOWABLE NITROGEN OXIDE EMISSION RATE (parts per million*)	ACTUAL NITROGEN OXIDE EMISSION RATE (parts per million*)
Ruston-TA 2500	2,500	150	73
Ruston-TB 5000	4,900	153	83
GE-MS 5001	25,000	150	66
GE-MS 5001P	34,000	167	102
GE-MS 5002R	33,500	208	181
GE-M 5352	35,000	173	100
GE-M 3142(J)	14,600	162	121
Cooper Rolls - RB 211-24	29,100	205	146
Solar Mars	13,000	198	135
Solar Centaur	3,950	164	98
Sulzer	7,700	150	143

*at 15% excess O_2

Air Monitoring. Although the purpose of establishing emission limits is to ensure that the air quality standards are being met, compliance cannot truly be verified without conducting ambient air monitoring. Air monitoring programs mandated by permits must follow stringent procedures to ensure that appropriate quality control is maintained and that the data meets EPA requirements (EPA 1980). Compliance is also required with quality assurance guidelines identified in 40 CFR 58, Appendix B, and with EPA reporting and surveillance provisions (EPA 1979a and 1979b).

Even though there has been considerable data indicating that permit emission limits are met by Prudhoe Bay operations, there has been growing concern over whether the ambient air standards are being met on the North Slope. An examination of the results of ambient air monitoring programs can put these concerns to rest.

The Prudhoe Bay operators conducted monitoring on the North Slope from April 1979 through March 1980 to determine the ambient air quality prior to the start of a major expansion program. This program was designed in consultation with EPA by a third-party independent contractor subject to EPA's quality assurance and quality control guidelines. EPA required this program as a prerequisite for obtaining air permits for the new facilities. In 1979, the capacities of the gas-fired turbines in operation at Prudhoe Bay totalled approximately 600,000 horsepower, while the gas-fired heaters in operation had a combined capacity of 770 million BTU/hour.

All ambient levels of air pollutants measured in the 1979-80 monitoring program were well below the limits set by the national standards, with the exception of a one-time exceedance of the primary standard for total suspended particulates. This isolated event was attributed to wind-blown dust and not to equipment emissions. Wind speeds during the sampling period averaged above 45 miles per hour, with gusts to 60. Since this one-time exceedance for particulates is allowed by federal regulations, the air quality standards were not in fact violated. The results of this monitoring program set the baseline air quality levels from which the incremental limits for sulfur dioxide and particulates were determined.

As a result of the facility expansions, another monitoring program was required following construction. The Alaska Department of Environmental Conservation received responsibility for air permitting in Alaska several years after completion of the 1979-80 monitoring program. ADEC, in consultation with EPA, required this post-construction monitoring to determine if the only criteria pollutant of concern, nitrogen dioxide, was meeting the national standards and whether the general air quality in the Prudhoe Bay vicinity was sufficiently better than the standards to allow continued industrial expansion.

Two ambient air monitoring programs were thus begun in 1986 to monitor the post-construction ambient air quality. These programs, which were developed by the North Slope operators in cooperation with the Region 10 office of the EPA and with ADEC, are still in operation. The programs are being implemented by independent third-party contractors. Expansions of the Prudhoe Bay facilities resulted in capacities of the gas-fired turbines in operation increasing to approximately 1,850,000 horsepower, while the gas-fired heaters in operation increased to a capacity of approximately 3,650 million BTU/hour.

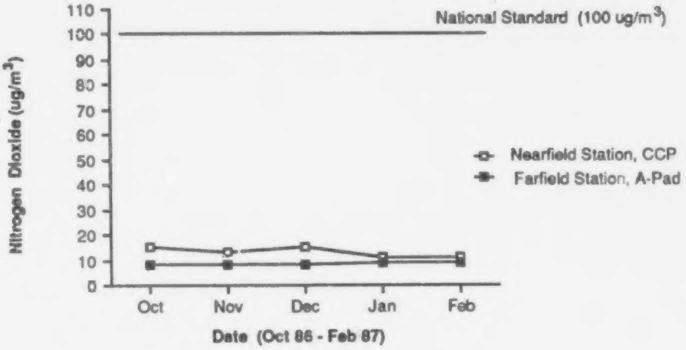
In the current programs, "near-field" and "far-field" monitoring stations were instituted for both the Kuparuk River Unit and the Prudhoe Bay Unit. The near-field stations assess the ambient air quality at each Unit's site of maximum predicted air quality impact, while the far-field stations assess background air quality levels several kilometers downwind of the production facilities. Air monitoring data collected from the permit-stipulated programs must follow EPA guidelines for reporting, site surveillance, and quality control.

At the Prudhoe Bay Unit, the near-field station at the Central Compression Plant (CCP) is directly downwind from a facility that operates thirteen 25,000-horsepower gas-fired turbines -- the largest single concentration of emission sources on the North Slope. Data from the first seven months of this monitoring effort have identified ambient air concentrations that do not even approach limits set by the national standards, including the incremental limits.

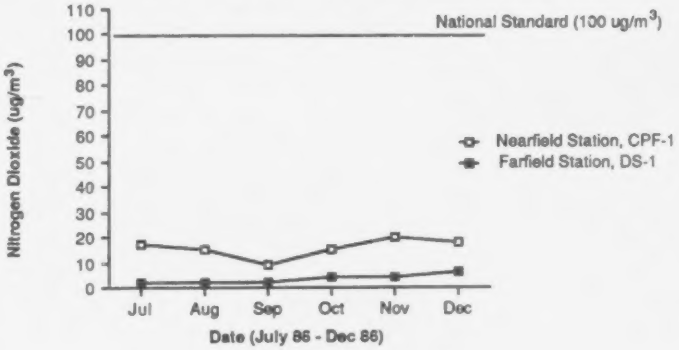
Data from the four monitoring stations are shown in Figures 2 through 6. Figure 2 shows that the concentration of the pollutant of most concern, nitrogen dioxide, is consistently below 20 percent of the most stringent standard of 100 micrograms per cubic meter. As shown in Figure 3, ambient levels of sulfur dioxide are consistently less than the most stringent 24-hour standard of 91 micrograms per cubic meter, which is the allowable level set by the increment for Prudhoe Bay (the national standard is 365 micrograms per cubic meter). Annual average values for sulfur dioxide from the 1986 monitoring programs are not yet available for comparison; however, the low daily values obtained so far indicate that the annual average will be similarly below the maximum set by the standards.

Particulate data from the monitoring programs indicate that wind-blown dust causes elevated levels of particulate matter in the air (Figure 4). It must be recognized that these concentrations are not due to emissions from oil production facilities. In fact, large amounts of dust are naturally present in the air on the North Slope during the brief summer. Sand dunes, river deltas, and other geographic features around Prudhoe Bay contribute significantly to elevated particulate levels in the air when dust is stirred up by winds. During the nine-month period of snow cover, particulate levels remain low.

Data shown in Figure 4 imply that the incremental limit for particulates of 41 micrograms per cubic meter was exceeded. The background air quality used to establish the incremental limit was obtained from the mean of all concentrations measured during selected periods of the 1979-80 Prudhoe Bay monitoring program. When compared with naturally occurring particulate levels, this increment is extremely stringent. Data around the "pristine" Mt. McKinley National Park show particulate levels as high as 64 micrograms per cubic meter (Stanley Consultants 1978). In addition, the EPA reports that average levels for particulates in rural areas range from 38 to 62 micrograms per cubic meter (EPA 1985). It is evident from the data that it is virtually impossible for naturally occurring particulate concentrations at Prudhoe Bay to remain below the incremental limit. With the imminent promulgation of a standard for fine particulates by EPA, this situation may change such that wind-blown particulates do not exceed any



Prudhoe Bay Unit Mean Monthly Nitrogen Dioxide Values

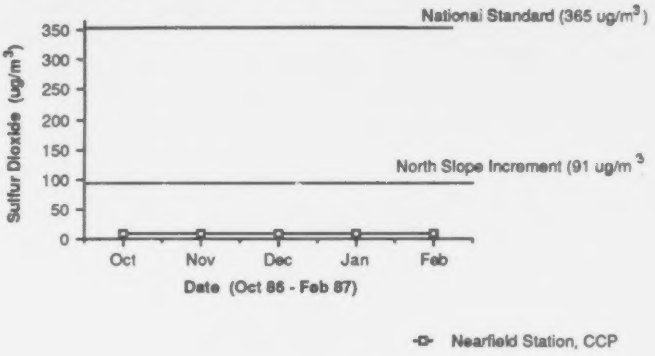


Kuparuk Unit Mean Monthly Nitrogen Dioxide Values

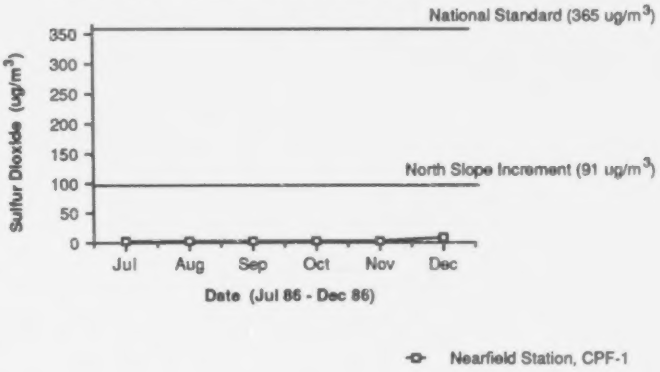
Note: The primary and secondary standards for nitrogen dioxide are identical. This standard is based on an annual average but is shown here against monthly values. In addition, incremental limits have not yet been established for nitrogen dioxide.

Source: ERT, 1987; ESE, 1986; and ESE, 1987

FIGURE 2



Prudhoe Bay Unit Maximum 24 -Hour Sulfur Dioxide Concentration



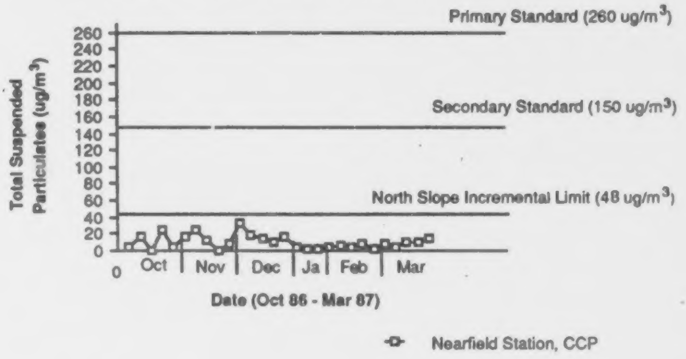
Kuparuk Unit Maximum 24-Hour Sulfur Dioxide Concentration

Note: There is not a 24-Hour secondary standard for sulfur dioxide.

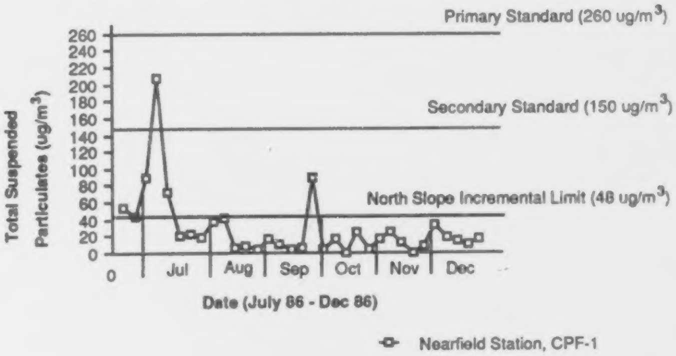
Source: ERT, 1987; ESE, 1986; and ESE, 1987

FIGURE 3

Prudhoe Bay Unit Maximum 24-Hour Particulate Concentrations



Kuparuk Unit Maximum 24-Hour Particulate Concentrations

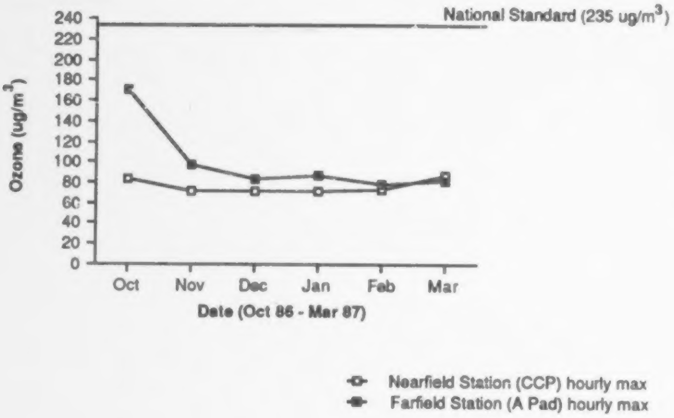


Note: Exceedances of the North Slope incremental limit are due to wind blown dust. There are not large contributions of particulates from equipment operated at Prudhoe Bay production facilities. In fact after September, when snow covers the area, there were no exceedances of the incremental limit.

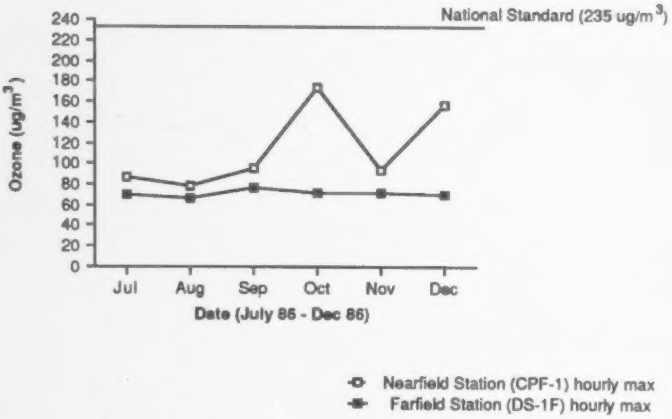
Source: ERT, 1987; ESE, 1986; and ESE, 1987

FIGURE 4

Prudhoe Bay Unit Maximum 1- Hour Ozone Concentrations



Kuparuk Unit Maximum 1-Hour Ozone Concentrations

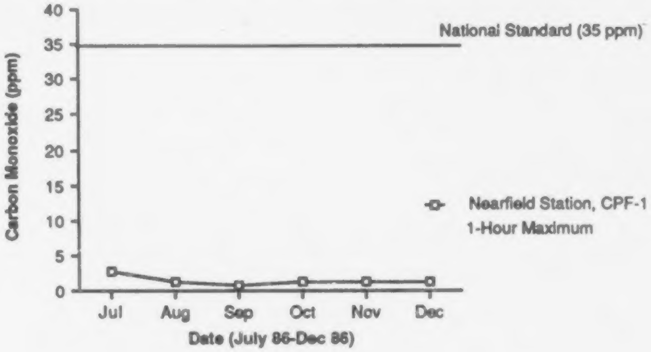


Note: The primary and secondary standards for ozone are identical. In addition, incremental limits have not yet been established for ozone.

Source: ERT, 1987; ESE, 1986; and ESE, 1987

FIGURE 5

Kuparuk Unit Maximum Hourly Carbon Monoxide Concentrations



Note: The primary and secondary standards for carbon monoxide are identical. In addition, incremental limits have not yet been established for carbon monoxide.

Source: ERT, 1987; ESE, 1986; and ESE, 1987

FIGURE 6

particulate concentration limits. Nevertheless, the naturally elevated particulate levels at Prudhoe do not exceed the primary standards, which insure that human health is not jeopardized.

Data for both ozone and carbon monoxide levels are well below the levels set by the most stringent standards (Figs. 5 and 6). Since there are no lead emissions from burning natural gas and since there are relatively few mobile emissions sources, no data is being collected on lead.

In summary, the post-construction monitoring data show that emissions from oil and gas production facilities do not detrimentally impact ambient air quality.

Comparison of Emissions from Large Cities to the North Slope

Statements that air pollution at the Prudhoe Bay oilfield is as bad as that in a large city are shown to be pure conjecture when the data are examined. The following discussion compares the ambient air quality of several large cities with that of Prudhoe Bay. The data clearly demonstrate that air quality at Prudhoe Bay is consistently better than that required by national standards, whereas levels of air pollutants in major cities frequently violate those standards.

Concentrations of carbon monoxide and ozone usually violate national standards in large cities because of automobile emissions. Such emissions are negligible on the North Slope, where few automobiles are in use. The New York City metropolitan area regularly violates the carbon monoxide national standard of 9 parts per million for an 8-hour period, with levels reaching as high as 17 parts per million (NYSDEC 1986). Los Angeles also exceeds the carbon monoxide standard, with levels as great as 22 parts per million, while Washington, D.C. experiences levels of 14.6 parts per million (SCAQMD 1986; Feigersh 1987). Maximum concentrations at Prudhoe Bay have never exceeded 1 part per million (ESE 1986; ESE 1987). New York City also violates standards for ozone, with hourly concentrations as high as 370 micrograms per cubic meter, compared to the hourly standard of 235 (NYSDEC 1985). Los Angeles exceeds the ozone standards approximately 40 percent of the year with concentrations as high as 764 micrograms per cubic meter, which is greater than three times that allowed by the standard (SCAQMD 1986). Ambient levels of ozone in Washington, D.C. also violate standards, with levels reaching 292 micrograms per cubic meter (Feigersh 1987). Even downwind of the major emission sources, the ozone levels at Prudhoe Bay average approximately 55 micrograms per cubic meter and have never exceeded 175 micrograms per cubic meter (ERT 1987; ESE 1986; ESE 1987).

Heavily industrialized cities also have problems with sulfur dioxide emissions from burning fuels with a high sulfur content, while North Slope oilfield operations burn low-sulfur natural gas. The maximum 24-hour sulfur dioxide concentration at Prudhoe Bay is below 10 micrograms per cubic meter, in contrast to the standard of 365 (ERT 1987; ESE 1986; ESE 1987). For the New York City metropolitan area, however, 24-hour sulfur dioxide concentrations have reached as high as 198 micrograms per cubic meter (NYSDEC 1986). The daily maximum for Los Angeles is within the standard at 60 micrograms per cubic meter, while Washington, D.C. levels reach 125 micrograms per cubic meter (SCAQMD 1986; Feigersh 1987).

Data from compulsory air quality monitoring programs clearly show the marked difference in air quality between Prudhoe Bay and large cities -- not only in levels of carbon monoxide, ozone, and sulfur dioxide, but for nitrogen dioxide as well. Los Angeles nitrogen dioxide levels are six times greater than those found at Prudhoe Bay, while New York City levels are four times greater. The national standard is an annual average of 100 micrograms per cubic meter. Los Angeles averages as high as 118 micrograms per cubic meter annually, the New York City metropolitan area averages 68, and Washington, D.C. averages 74 (SCAQMD 1986; NYSDEC 1986; Feigersh 1987). Monthly average concentrations downwind of Prudhoe Bay are consistently below 15 (ERT 1987).

Data for total suspended particulates are not relevant for comparison. The largest source of elevated levels of particulates is wind-blown dust, not emissions from large cities or industrial areas. Data do indicate, however, that the levels of suspended particulates in Prudhoe Bay, Los

Angeles, and New York City usually meet the ambient air quality standards. In addition, the three locations have all been shown to meet the ambient air quality standards for the remaining criteria pollutant -- lead.

Data from government-mandated monitoring programs prove that Prudhoe Bay air quality consistently meets national standards and is not comparable to major urban areas such as New York City, Washington, D.C., and Los Angeles.

Arctic Haze

The presence of the phenomenon known as arctic haze is another issue that has been raised regarding North Slope air quality. Arctic haze was first described in the Arctic in 1956, long before the presence of any North Slope oil and gas production facilities (Rahn 1984). This pervasive haze is due to the presence in the air of minute particles, such as aerosols. Research indicates that oil and gas production facilities on the North Slope do not contribute to this haze.

Investigators believe that arctic haze comes from the long-range transport of industrial pollutants from the middle latitude regions of Eurasia. An emissions fingerprinting process has shown that emissions typical of Europe and Asia match those found in the haze (Raatz et al. 1985; Rahn 1984). Concentrations of the arctic haze are typically low at ground level, increase with elevation to a maximum concentration, and then decrease again. The maximum concentrations are commonly found at altitudes of several thousand meters.

Because the haze is found at high altitudes directly above Prudhoe Bay, scientists believe that local emission sources do not contribute to this haze. Long distances of transport are needed for pollutants emitted near the ground to be lifted to these altitudes. Also supporting the unlikelihood of haze contributions from Prudhoe Bay is the fact that arctic haze undergoes a pronounced seasonal variation characterized by a winter maximum and a summer minimum. Investigators have shown that the seasonal variation is directly related to results from the seasonal variation in atmospheric transport and removal mechanisms associated with transportation of pollutants from the mid-latitudes of Eurasia.

During an overflight at Prudhoe Bay in 1986, the National Oceanic and Atmospheric Administration (NOAA) found no contribution to arctic haze from oil and gas production facilities (Schnell, 1987). Arctic haze was present at altitudes from several hundred meters to 6,000 meters. However, data collected on the ambient air quality at the ground, which includes emissions from the Prudhoe Bay facilities, did not match the arctic haze fingerprint.

Conclusion

In summary, the following points are evident from this paper:

1) First, there are sufficient data demonstrating that levels of air pollutants downwind of the Prudhoe Bay oilfield are well below half the level of the federal standards.

2) Secondly, Prudhoe Bay air quality is much superior to that in large cities. In fact, Prudhoe Bay air quality is consistently better than the standards, while air pollutant levels in large cities frequently violate these standards.

3) Emissions from Prudhoe Bay oil and gas facilities do not contribute to arctic haze on the North Slope.

If a field such as Prudhoe Bay is discovered in the 1002 area of the Arctic National Wildlife Refuge, development of this field would utilize facilities similar to those currently in operation at Prudhoe Bay. Prior to operation of any new facilities, proposed emissions would be regulated by the Alaska Department of Environmental Conservation and the U.S. Environmental Protection Agency, and the operators would have to demonstrate that acceptable levels of air quality are met for the proposed development. Based on the excellent air quality record of Prudhoe Bay and the regulatory mechanism in place, it is clear that any oil and gas development in the 1002 area will not detrimentally affect existing air quality.

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PRODUCTION WASTE

FEDERAL REGULATIONS

- Oil and gas production waste is currently exempt from classification as hazardous under RCRA.
- EPA is studying the wastes to determine if there is a need to further regulate them and will submit a report to Congress by 12/30/87.

NEW STATE REGULATIONS TO BE PROMULGATED JULY 1987

- State water quality standards (WQS) must be met 50 feet from a reserve pit.
- Regulations require retrofit or close out of pits if WQS are not met.
- Regulations allow the use of fluid management techniques to attain compliance:
    1. Snow removal.
    2. Tundra dewatering or road watering if water meets WQS.
    3. Annular injection or injection wells if water does not meet WQS.

CURRENTLY EXEMPT PRODUCTION WASTE

CATEGORY	HANDLING PRACTICE	ANNUAL VOLUME (bbl)
1. Mud and Cuttings	Reserve pits	1,000,000
2. Produced Water	Injection	100,000,000*
3. Associated Wastes		300,000
Work over fluids	Reserve pits	
Wastewaters	Reserve pits/Injection	
Tank bottoms	Injection	
Untreatable emulsions	Injection	
Pig trap solids	Recycle	
Waste lubricating oils	Recycle	
Waste crude oil	Recycle	
Oily debris	Incinerate/Landfill	

---

* About two-thirds of the produced water (included in the 100,000,000 bbls) is not a waste product because it is recycled for enhanced recovery.

RESERVE PITS

Reserve Pit Use

- Reserve pits are used for the containment of drilling muds and rock cuttings as well as drilling fluids and associated liquid wastes.
- Drilling muds used on the North Slope are predominantly water-based muds.
- When oil-based muds must be used they are tanked and reinjected into a well annulus and not discharged to reserve pits.

Reserve Pit Waste Characterization

- Liquid samples measured in a Standard 1986 study showed:
  - No measurable volatile organic compounds were present;
  - No samples exhibited hazardous waste characteristics (under EPA's proposed toxicity characteristic leaching procedure (TCLP) test).
- Solid samples measured in the Standard 1986 study showed:
  - Low levels of the volatile compounds ethylbenzene and toluene were found. These were below EPA's proposed TCLP standards.
  - No samples exhibited hazardous waste characteristics.

Reserve Pit Fluid Disposal Practices

The following practices can be used for removal of liquids from reserve pits:

- Snow removal;
- Discharge fluids, that satisfy State Water Quality Standards, to the tundra or roads;
- Inject pit fluids via well annulus or injection wells.

Reserve Pit Water Discharge Criteria

- In order for reserve pit liquids to be discharged to the tundra or used for road watering, criteria similar to State Drinking Standards must be met for:

  Metals (arsenic, barium, cadmium, chromium, lead, manganese, mercury, silver); settleable solids; visible sheen; aromatic hydrocarbons; chemical oxygen demand; total oil and grease; and pH;
- Additionally, State standards for total dissolved solids (TDS), which is a measure of salinity, must be met to prevent damage to vegetation.
- Reserve pit fluids must go through one freeze/thaw cycle to remove solids prior to qualifying for tundra discharge.

- Reserve pit liquid samples must be analyzed and submitted to the State for review prior to a permit issuance before tundra discharge occurs.
- New regulations promulgated by the State in July of 1987 requires an increased sampling frequency during discharge to monitor water quality levels. All samples must be taken after complete thaw of the reserve pit fluids so that adequate mixing can occur and samples will be representative.

Permits Required for Construction of Reserve Pits

The following permits are required for construction of reserve pits:

- Federal permit (COE 404); and
- State Solid Waste Disposal permit.

Construction Technology for Production Reserve Pits

- Construction in the summer with thawed gravel;
- Shorter gravel lifts for better compaction of walls;
- Increase silt content of gravel to reduce permeability.

Construction of Exploration Reserve Pits

- Below-ground construction in the permafrost is required for exploration wells to allow for an impermeable frozen confining area surrounding the walls and floor of the reserve pit.

CLASS II UNDERGROUND INJECTION WELLS USE IN OIL AND GAS PRODUCTION FACILITIES

Enhanced Recovery Wells (EOR)

- These are used at production facilities for the injection of produced waters and seawater into the oil producing formation for increased recovery of oil reserves.
- In 1986, two-thirds of the produced waters generated at Prudhoe Bay were used for enhanced recovery.
- Treated seawater is used as an additional source of water for EOR operations.
- As of March 1986, there were 45 EOR wells at Standard's Prudhoe Bay operated facilities.
- Wells average depths are 8100 to 8600 feet below the surface.
- Over the life of the Prudhoe Bay Field, enhanced recovery practices are expected to increase yield of oil by 12%.

Fluid Disposal Wells

- Residual produced waters and comingled production wastewaters are injected into non-oil-producing formations.
- There are 7 disposal wells located at Standard's production facilities at Prudhoe Bay.
- The average well is 6,000 feet below the surface.

Construction and Operation of Wells

- Construction and operation of wells are regulated through a permit system administered under the Underground Injection Control (UIC) Program through the Alaska Oil and Gas Conservation Commission.
- Surface and subsurface safety devices are used in wells to guard against spills.
- Automatic shut-in equipment and monthly reporting of pressure volume and flow rates are required under the UIC Program.
- Restrictions on injection pressures are required on EOR wells.
- Absence of any underground sources of drinking water at Prudhoe Bay makes underground injection a particularly safe practice in the Arctic.

Characteristics of Produced Water Used for Enhanced Recovery and Disposal

- Samples of produced water tested in 1986 did not exceed any current RCRA standards set for hazardous wastes.

HAZARDOUS WASTE

AMOUNT OF HAZARDOUS WASTE

- SAPC generated approximately 300 bbls at Prudhoe Bay in the Western Operating Area in 1986. (ARCO volume should be similar.)

SOURCES OF HAZARDOUS WASTE AT PRUDHOE BAY

- Hazardous waste streams are generated from construction, maintenance and production processes.

TYPES OF HAZARDOUS WASTE

The following types of wastes streams are generated by Standard at Prudhoe Bay in these approximate percentages:

o Paints, waste oils and solvents (ignitables)	64%
o Spent acids/bases and lab wastes	18%
o Miscellaneous	18%

HANDLING OF HAZARDOUS WASTE

In 1986, Standard handled their hazardous wastes generated at Prudhoe Bay in the following manner:

- 26% of the waste generated were recycled or reclaimed on-site.
- 68% of the wastes were sent for off-site recycling.
- 6% of the wastes were sent off-site for disposal by incineration.

INCINERATION

- No permitted commercial treatment or disposal facilities exist in Alaska.
- Hazardous wastes are sent out-of-state by truck, by licensed carriers.

LOCATION OF PERMITTED INCINERATION FACILITIES

No commercial hazardous waste disposal facilities exist in Alaska so hazardous wastes are sent to the following facilities for disposal:

- SAPC ships to Rollins (Texas)
- ARCO ships to Chem Waste Management (Chicago)

No hazardous wastes are sent to the North Slope Borough Landfill or Incinerator on the North Slope.

RECYCLING/RECLAMATION

- SAPC and ARCO are registered hazardous waste generators.
- SAPC and ARCO both operate a RCRA-permitted interim-status storage facilities for hazardous waste.
- SAPC continues to research on-site recycling technologies for hazardous wastes (used motor oil and hydraulic fluid).
- ARCO is seeking a RCRA permit for a Class I hazardous waste injection well facility for safe disposal of liquid hazardous waste at Prudhoe Bay.

ARCTIC OIL AND GAS
EXPLORATION AND PRODUCTION WASTES

March 9, 1987

A Report Prepared by
THE STANDARD OIL COMPANY

EXECUTIVE SUMMARY

This report was prepared for the U.S. Environmental Protection Agency by the Standard Oil Company, which operates the western half of the Prudhoe Bay Oil Field on Alaska's North Slope. This report will help EPA to prepare the Arctic portion of its report on the oil and gas industry waste mandated under Section 8002(m) of the Resource Conservation and Recovery Act.

This report describes the unique aspects of arctic oil and gas exploration and production and the management of the waste drilling muds, produced water, and other associated wastes generated in these operations. Standard has two decades of experience exploring for and producing oil and gas on Alaska's North Slope. This experience shows that while these wastes are similar to those generated in oil fields in temperate climates, the unique features of the arctic environment call for different management techniques and create unique impact considerations.

After examining the potential for impact via air, ground water, and surface water, Standard has concluded that the only possible scenario of regulatory concern is fluid release from reserve pits. This potential for release can be minimized by a number of management techniques described in the report. Proposed amendments to the Alaska Solid Waste Disposal Regulations (to be promulgated in the summer of 1987) will promote the use of these techniques.

The potential "receptor of concern" for fluids released from reserve pits is vegetation rather than humans or animals. Numerous studies and Standard's operating experience show that the effects on vegetation are minor and short-term. Because of the relative insignificance of these impacts, the application of modeling does not appear to be warranted. Nevertheless, simplified modeling techniques applicable to the Arctic are included for EPA's consideration.

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CHAPTER 1 UNIQUE ASPECTS OF ARCTIC OPERATIONS

This chapter describes how the harsh environment on the North Slope of Alaska causes oil and gas exploration and production, and the waste management practices associated with these operations, to differ from petroleum operations in the rest of the United States. First, the climate and unique hydrogeological features of the North Slope are presented. Then, the ways in which drilling operations and waste management practices have evolved to adapt to these special conditions are described.

1.1 ENVIRONMENTAL SETTING

The North Slope of Alaska, a region covering approximately 76,000 square miles, is located 250 miles north of the Arctic Circle. The North Slope extends along the northern part of Alaska from the foothills of the Brooks Mountain Range to the shore of the Beaufort Sea. The oil and gas production facilities of the Prudhoe Bay Unit (East and West Operating Areas), the Kuparuk River Unit, the Milne Point Unit, the Endicott Unit, and the Lisburne Unit are located within this area along a narrow band between the Colville and the Sagavanirktok rivers (60 miles long and 10 miles wide). Approximately 1.8 million barrels of oil per day (about 20 percent of the U.S. oil production) are produced from these facilities. The Alaskan Arctic also contains over 33 percent of the proven U.S. oil reserves and over 12 percent of the U.S. gas reserves.

The North Slope is a vast windswept area, typified by extremely long, cold winters and brief, cool summers. During the winter, temperatures drop as low as 60°F below zero, with high winds driving the wind chill to 115°F below zero. The average temperature rises above freezing only during the months of June through August. The mean annual temperature is 9°F above zero.

As a result of the extremely cold temperatures, the ground remains frozen approximately nine months of the year. During the brief summer period, only the top 18 to 36 inches of soil thaw. The ground below this surface layer, down to a depth of approximately 2,000 feet, remains permanently frozen year round. Ground in such a permanently frozen state is called permafrost.

The permafrost zone plays a major role in the subsurface and surface hydrology on the North Slope. No ground water exists within the permafrost zone, which effectively restricts infiltration and recharge to ground water that may exist below the permafrost. Ground water below the permafrost is saline, with dissolved solids levels generally above 7,000 milligrams per liter (mg/l).

Although the North Slope has an annual precipitation rate of less than 5 inches of water, the area is characterized by wetlands and braided streams, as well as shallow lakes and ponds. During the limited ice-free season, water covers approximately 30 to 90 percent of the tundra surface. This phenomenon occurs because the permafrost essentially confines all the precipitation to a shallow surface layer of soil and because the flat terrain prevents rapid surface runoff.

During the spring thaw (a period called breakup) the ice and snow melt rapidly causing the surface water to move by sheet flow to nearby drainages and streams. Although there is extensive surface water on the North Slope, drinking water sources are confined to a few natural deep lakes and to man-made water reservoirs near the major rivers. Most lakes are shallower than 6 feet and freeze to the bottom during the winter.

1.2 DRILLING OPERATIONS

Drilling sites are built on five-foot-thick gravel pads to minimize any impact on the underlying permafrost. The pads serve both to insulate the permafrost and to support heavy drilling equipment. If drilling sites were not elevated on gravel pads, some thawing of the permafrost would occur.

Numerous wells are drilled from each gravel pad on the North Slope. This is accomplished by the use of an offshore drilling technique called directional drilling. With this technique, the wells from each pad can collectively produce oil from the petroleum reservoir within approximately a two-mile radius of the surface location. Therefore, the "gravel footprint" of the drillsite, and its associated damage to the tundra, is minimized. After the drilling rigs are removed, metal houses are placed over each well to protect each wellhead and its controls from the harsh arctic climate.

1.3 DRILLING WASTES

The type and quantity of drilling waste generated on the North Slope, as well as the units used to contain it, are significantly affected by the unique arctic environment. This section first describes the special mud systems used in the Arctic and practical constraints on mud recycling. The section then describes the special design features of reserve pits in the Arctic used to deposit cuttings and spent muds that are not recycled.

1.3.1 Mud Systems

Water based mud systems are the predominant drilling fluids used in the Arctic, and even though oil-based muds are more expensive and harder to handle than water-based muds, oil-based muds are sometimes needed for directional drilling on the North Slope. Directional drilling entails creating angled bore holes (some horizontal). The superior lubricating qualities of oil-based muds are often needed to overcome the unusually high frictional forces associated with this type of drilling. Oil-based muds are also preferred for certain coring operations because, compared to water-based muds, they minimize potential fluid invasion damage to the core.

In 1986, oil-based muds were used at four of the 39 wells drilled in the Western Operating Area of the Prudhoe Bay Unit. However, only two mud systems were actually mixed for these wells, because the muds for the first two wells were reused on the next two wells. Spent muds from oil based drilling are stored between uses in tanks (as opposed to reserve pits) and eventually disposed of by underground injection. Reserve pit deposits from oil-based muds on the North Slope are limited to drill cuttings.

Arctic mud systems must be enclosed to protect them from sub-zero temperatures. Except for oil-based muds, which are usually mixed at the supplier's site, muds on the North Slope are prepared indoors at the drill site within the confines of the winterized drilling rig specially designed to minimize space requirements. The need to conserve space and the cost savings resulting from mud reuse serve as strong incentives to recycle muds as much as possible.

The average well's mud in the Arctic is recycled 100 to 300 times during the drilling of a well. Recycling involves cleaning the circulating mud to prevent build-up of solids and cuttings. The rig equipment used for this purpose routinely includes: shale shakers, which serve as a screen; desanders, desilters, and centrifuges, which provide centrifugal force; and chemical flocculents to enhance settling. The equipment is sized to treat nominal circulating volumes. Space requirements preclude up-scaling the equipment to accommodate occasional high circulating rates.

Increased circulating rates are necessary for numerous reasons. For example, drilling soft rock can result in high penetration rates, which may require a circulating mud volume that exceeds the treatment capacity of the equipment (e.g., the centrifuge). Also, water may have to be added to dilute that portion of the mud that cannot be treated before reuse -- thereby exacerbating the excess volume problem. Because space limitations preclude storage of large volumes of mud on the drill rig, some mud must be disposed of rather than recycled.

In addition to capacity shortfalls, technological limitations prevent recycling of muds in certain situations. For example, drilling in permafrost requires high-viscosity muds which cannot be treated effectively for use in deeper sections of the well. Also, specially weighted muds, which are prepared to hold back shale and producing formation pressures until cemented steel casings are installed, cannot always be diluted quickly enough for subsequent reuse. Without dilution, these muds could cause lost circulation, well control problems and formation damage. Thus, dilution and disposal of these muds is sometimes required.

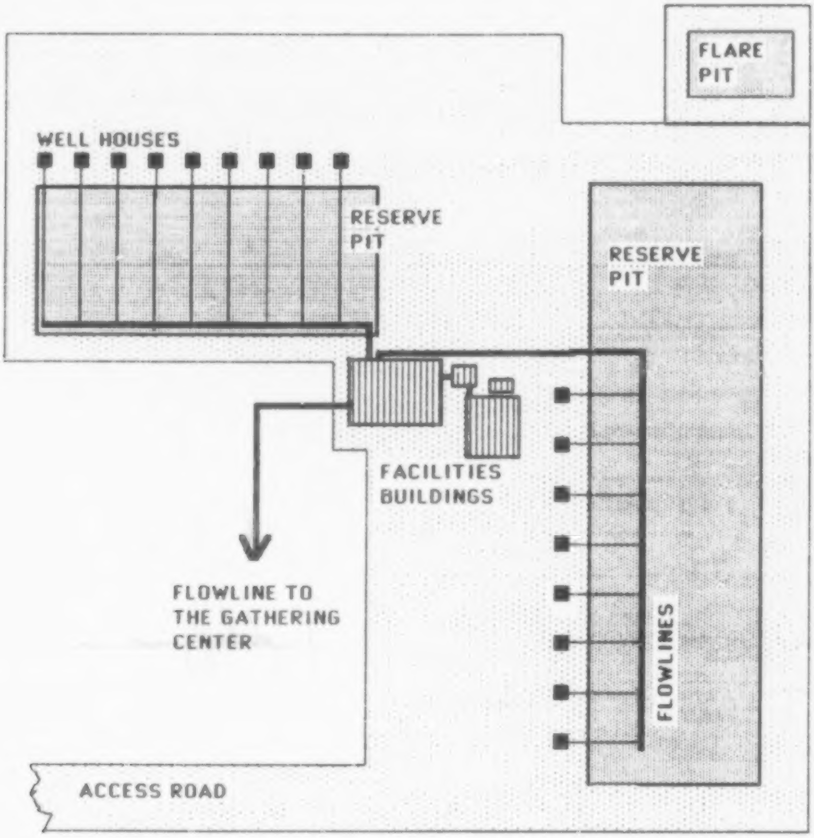
1.3.2 Reserve Pits

Because numerous wells are drilled at each pad, centralized reserve pits are used to contain the waste drilling fluids and cuttings generated at the pad. The reserve pits continue to accept development drilling and workover wastes for the life of the pad. This differs from the typical practice in the lower 48 states, where a separate reserve pit is built for each well. With the use of centralized pits, less tundra is disturbed than if multiple, well-specific pits are built. Figure 1 illustrates a typical arctic well pad design.

Like the rest of the well pad, reserve pits on the North Slope are generally built above-grade and are constructed of gravel. Where relatively small quantities of waste are generated (e.g., exploration wells) below-ground reserve pits are sometimes used. For both above- and below-grade reserve pits, the underlying permafrost acts as an impermeable barrier to prevent downward migration of waste constituents.

Drilling fluids placed in the reserve pits are frozen for about nine months of the year. When the pit fluids freeze, they freeze from the top down, concentrating the suspended and dissolved solids in the bottom of the pit. In the summer as the ice melts, the cleaner upper layer of melt water often can satisfy State Water Quality Standards and can be discharged directly to the tundra under a State discharge permit. Thus, reserve pits in the Arctic serve as short-term containment devices for some waste components (e.g., melt water) and long-term disposal units for other waste fractions (e.g., rock cuttings and mud solids).

FIGURE 1
EXAMPLE OF AN ARCTIC WELL PAD DESIGN



1.4 PRODUCED WATER

The absence of an underground source of drinking water (USDW) within the production areas of the Prudhoe Bay Unit on the North Slope makes injection of produced water a particularly safe management practice. The dissolved solids content (above 7,000 mg/l) of the ground water -- which is located below the permafrost layer -- is so high that EPA Region X exempted the aquifer as a USDW in 1986. The ground water was deemed to be not economically recoverable as a source of drinking water.

This favorable environmental setting for underground injection is a major reason why the practice is so heavily relied upon in the Arctic. This section describes the unique aspects of underground injection of produced water on the North Slope. Injection for enhanced recovery will be discussed first, followed by injection for disposal.

1.4.1 Enhanced Oil Recovery

Waterflooding is a secondary recovery technique used at Prudhoe Bay. Water is injected underground to maintain sufficient pressure in the petroleum reservoir and to move oil and gas towards the producing wells. Produced water from the gathering centers is used and is supplemented by treated water from the Beaufort Sea. The $2 billion waterflooding project at Prudhoe Bay will ultimately inject about 2.2 million barrels per day of seawater, and another million barrels per day of produced water, into the producing formation, located at a depth of approximately 9,000 feet.

Produced water injected for enhanced recovery is an integral part of the production process at Prudhoe Bay and thus is not a solid waste. Over the life of the Prudhoe Bay field, waterflooding will increase production by approximately 830 million barrels of oil. This translates into an additional yield of about 12 percent.

If produced water were not used, additional seawater would have to be treated and injected at substantial additional cost. For one arctic operator alone, this would increase production costs over the next three years by approximately $50,000 per day. Produced water used for secondary recovery is not a solid waste because its use constitutes a legitimate recycling step in the production of oil on the North Slope.

1.4.2 Disposal Wells

Some produced water has such a high suspended solids content that it cannot be used for enhanced recovery. This water is injected below the permafrost into the Cretaceous zone at a depth of approximately 6,000 feet. Piping in arctic operations is above ground and is easily observable.

CHAPTER 2 ARCTIC WASTE MANAGEMENT PRACTICES

Wastes generated in the Arctic from oil and gas exploration and production are similar to those generated in other areas of the United States. However, as illustrated in Chapter 1, unique practices to manage these wastes have evolved in response to the special conditions on the North Slope. This chapter provides greater detail on these waste management practices and on the wastes themselves.

Only production wastes are addressed in this chapter. Production wastes are organized in this chapter into three categories: reserve pit wastes, produced water and associated wastes. For each category, waste generation and composition data are presented first, followed by a discussion of applicable current and pending regulations, and finally, alternative waste management practices.

2.1 RESERVE PIT WASTES

As described earlier, spent drilling muds and cuttings are deposited in centralized, above-ground reserve pits. The pits remain open for as long as the field is in operation so that they are available for ongoing development drilling and workovers. Consequently, the size of each reserve pit and the volumes of waste deposited therein are much greater than in the lower 48 states.

2.1.1 Waste Generation

Each well in the Prudhoe Bay Unit generates about 15,000 barrels of mud and 3,000 barrels of cuttings, for a total of about one million barrels of waste for the 62 wells drilled there in 1986. Extrapolating from waste accumulation data for 46 pits, about 26 million barrels of muds and cuttings are presently contained in reserve pits in the Prudhoe Bay Unit.

In 1986, sampling was conducted on several reserve pit wastes in the Prudhoe Bay Unit. Liquid and solid waste samples were taken from both old (1971) and recently constructed (1984) pits. Waste composition data are presented separately for the two fractions.

Liquids. Liquid samples were taken from four reserve pits. No measurable quantities of volatile organic compounds were detected, nor did the samples exhibit any of the hazardous waste characteristics, even when using the proposed toxicity characteristic leaching procedure (TCLP). See Appendix A for the quantities of contaminants detected.

Table 1 compares the above-referenced waste analysis data for the liquid samples to the regulatory thresholds under the State of Alaska's Water Quality Standards. The standards are designed to protect the designated uses (e.g., fishing, swimming, drinking) for the various water bodies in the State. The standards are solely health-based and are at least two orders of magnitude more stringent than the regulatory thresholds for metals under the proposed TCLP. The Alaska standards are relevant as benchmarks to assess risk for situations that might involve the direct discharge of contaminants to surface waters.

Three of the four liquid samples analyzed exceed the Alaska standards for chemical oxygen demand (COD) and barium; and all exceed the standards for chromium and manganese. None of the samples exceed the standards for total recoverable oil and grease (TROG).

Solids. Solid samples were taken from four pits and from a shale shaker on a drilling rig. Measurable quantities of the volatile compounds ethylbenzene and toluene were detected (See Appendix A). However, none of the samples exhibited any hazardous waste characteristic, including the proposed TCLP levels for ethylbenzene and toluene. Comparisons to the Alaska Water Quality Standards are not presented for reserve pit solids because, unlike reserve pit liquids, the solids are managed in a way that they could not be directly discharged to surface waters.

TABLE 1

COMPARISON OF RESERVE PIT LIQUID DATA (WESTERN OPERATING AREA) TO ADEC WATER QUALITY STANDARDS

ADEC STANDARDS*	PAD 1 (mg/l)	PAD 2 (mg/l)	PAD 3 (mg/l)	PAD 4 (mg/l)
COD (200 mg/l)	250	140	260	390
TROG (15 mg/l)	ND	3.5	1.9	0.6
TSS (no increase above background)	250	4900	532	32
TDS (1500 mg/l or 1/3 over background, whichever is less)	NA	NA	NA	NA
pH (6.0 - 9.0)	8.02	8.18	7.91	8.53
As (0.05 mg/l)	0.006	0.004	0.008	0.016
Ba (1.00 mg/l)	3.8	3.9	0.29	4.4
Cd (0.01 mg/l)	ND	ND	ND	ND
Cr (0.05 mg/l)	0.45	0.53	0.11	0.22
Pb (0.05 mg/l)	ND	ND	ND	ND
Mn (0.005 mg/l)	0.31	2.2	0.30	0.18
Hg (0.002 mg/l)	ND	ND	ND	ND

*All criteria are for water supplies except for TDS, which is based on aquatic toxicity.

NA = No analysis performed

ND = Not detected

COD = Chemical oxygen demand

TROG = Total recoverable oil and grease

TSS = Total suspended solids

2.1.2 Management Practices Under the Existing and Pending Regulations

Numerous Federal, State and local permits must be obtained in order to construct and operate a reserve pit on the North Slope. This section addresses the requirements for only two of these permits: a Section 404 Clean Water Act (CWA) permit issued by the U.S. Army Corps of Engineers, and a solid waste disposal permit issued by the Alaska Department of Environmental Conservation (ADEC).

Section 404 CWA Permit. Most of the North Slope is characterized as wetlands, and thus a Section 404 CWA permit is required in order to discharge the fill material (mostly gravel) needed to construct the reserve pit. Gravel used to build reserve pits is extracted from deadarms of nearby rivers. (A deadarm is a a bend in a river, or oxbow, which is abandoned as the river changes course.) As administered by the COE, a public interest review is conducted for each proposed construction project on the North Slope, including an evaluation using EPA's Section 404(b)(1) guidelines.

The Corps of Engineers has developed a specialized procedure (APP 83-1) for processing Section 404 permits for oil and gas projects on the North Slope. The procedure has both general and special conditions. The general conditions (a through u) address the basic requirements for permit issuance, revocation and modification. Examples of these conditions are: compliance with applicable water quality standards and CWA effluent limitations; a prohibition on discharges that harm threatened or endangered species or their habitats; and a requirement that the permittee make every reasonable effort to construct the proposed project so as to minimize any adverse impact on fish, wildlife and the natural environment.

The special conditions under APP 83-1 address, among other things, reserve pit design and the hydrology of the area. Reserve pits must be designed to be impermeable. Hydrocarbons discharged into the pits must be removed and properly disposed of as soon as practicable during the winter and within 72 hours of discovery during spring thaw.

The special conditions related to hydrology require that a minimum distance of 100 feet be maintained between the toe of the gravel pad and the ordinary high water mark of adjacent lakes and stream banks. They also stipulate that structures be installed to prevent erosion or drainage of adjacent aquatic areas. Furthermore, to minimize the destruction of tundra and other sensitive habitat, the applicant must utilize nonwetland areas and existing pads and roads to the maximum extent practicable.

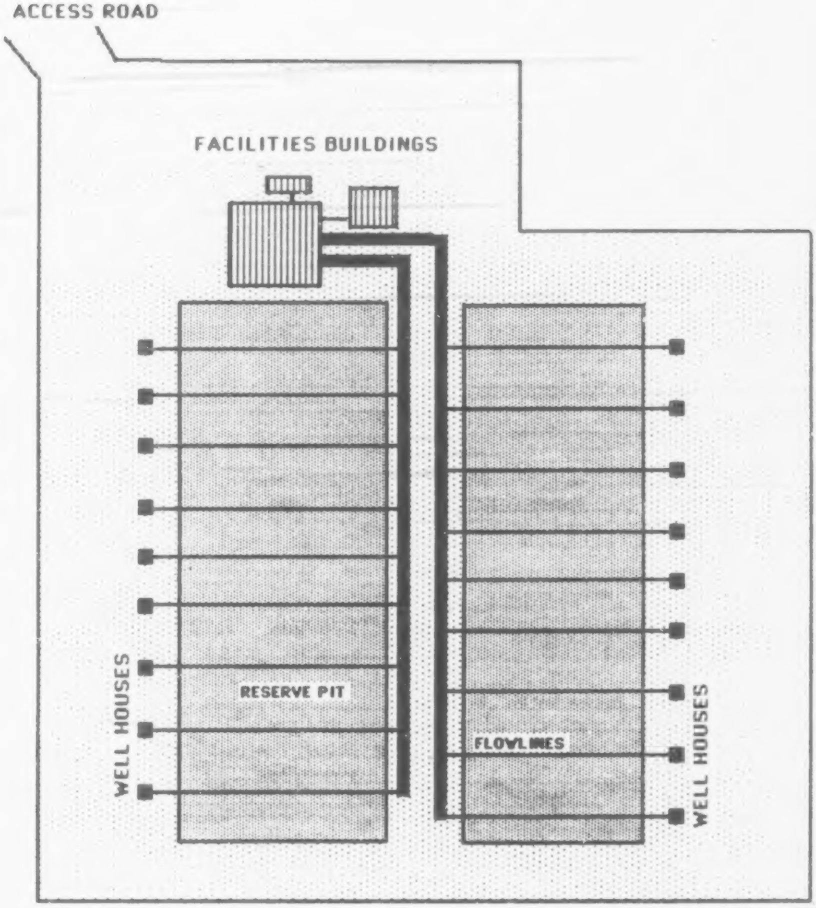
Solid Waste Disposal Permit. Like the Corps of Engineers' special conditions under APP 83-1, the ADEC's solid waste regulations require that the reserve pit be impermeable. The underlying permafrost satisfies this criterion for downward migration. However, even with recently developed construction techniques, revised regulations (proposed by the ADEC last year) acknowledge that an absolute "no lateral migration" requirement may not be achievable in the Arctic.

Reserve pit walls are constructed of gravel, and thus seepage through the walls has been known to occur. For recently constructed pits, new designs have reduced the seepage rate considerably. To render the walls less permeable, gravel with a higher silt content has recently been used, and the gravel lifts have been shortened in order to achieve greater compaction. Furthermore, new designs for the well pad itself in effect widen the reserve pit walls by reorienting the pits so that less of the reserve pit faces the tundra. Compare Figure 1, illustrating a typical well pad design, with a newer design shown in Figure 2.

Few options, if any, are available to render existing reserve pit walls absolutely impermeable. For this reason, the ADEC's revised rules propose to replace the existing design standard requiring absolute containment with a performance-based standard. The revised standard will require that the State Water Quality Standards cannot be exceeded at more than 50 feet from the facility.

Arctic operators are free to use any design or operating practice to achieve compliance with the water quality standards. One option is an operating practice known as "fluid management." Fluid management entails

FIGURE 2
REVISED ARCTIC WELL PAD DESIGN



the use of dewatering techniques to reduce the fluid level in the pit. The less fluid contained in the pit, the less seepage can occur through the pit wall.

The following dewatering techniques are currently practiced -- some more than others -- to reduce the fluid content of reserve pits in the Arctic.

1. Snow Removal. Drifting snow accumulates in reserve pits during the winter. Prior to spring breakup, clean snow is removed from the top of the frozen waste to reduce the volume of melt water that would otherwise be in the pit. However, for reserve pits with flowlines that run across the pit (see Figure 1), snow removal is hampered because the flowlines prevent heavy equipment from reaching and removing the snow.

2. Tundra Dewatering. In winter, the freezing process causes the solids in the waste to settle to the bottom of the pit. When the waste thaws, a clean upper layer of melt water is created that can be discharged to the tundra. To obtain a permit to discharge to the tundra, the ADEC requires that the melt water satisfy pre-discharge effluent limits and that no wastes be placed in the pit during the previous year.

3. Road Application. The ADEC also allows reserve pit fluids that satisfy the water quality standards to be used for dust suppression.

4. Annular Injection. For pit fluids not meeting the water quality standards, one fluid management option is to inject the fluids into available annuli. Production well annuli are available for injection of reserve pit fluids only during the summer when the fluids are thawed and only when the annulus is open. Once the well is completed, the annulus is sealed and is not available for further injection. While a production well is being drilled, the annulus is also used for disposal of drilling muds from that well. In the future, annuli will be reserved whenever possible and freeze protected for disposal of reserve pit fluids at the well pads during the summer thaw.

5. Disposal Wells. Where future drilling is not planned, perhaps the only remaining fluid management option is to inject the fluids into a disposal well. This would require that either special disposal wells be drilled at the well pad or that the waste be transported to existing disposal wells at production facilities called gathering centers.

The ADEC's proposed rules are scheduled to be promulgated this summer. Use of fluid management techniques should reduce lateral migration from reserve pits so that the performance standard in Alaska's pending regulations (i.e., compliance with the water quality standards at 50 feet) can be met.

2.1.3. Alternative Waste Management Practices

In certain cases, fluid management may not achieve compliance. Or, it is possible that a more stringent standard may ultimately be promulgated. This section describes additional waste management practices that might be contemplated to further reduce lateral migration.

Liners. Liners have been considered in the Arctic, but only for reserve pit walls. Because permafrost serves as a natural barrier to prevent downward migration, a liner would be superfluous on the bottom of a reserve pit.

Two approaches that have been tried involve retrofitting reserve pit walls with liners. Under the first approach, a liner is placed along the inner surface of the reserve pit wall. Installation must occur before the waste thaws, and requires that the waste be moved away from the wall. Experience to date has not been successful. Synthetic liners become brittle and lose their integrity when exposed to the harsh arctic elements.

The other approach is to dig a trench lengthwise through the middle of the reserve pit wall and install a liner inside the trench. In order to ensure maximum wall integrity, installation must occur before the wall thaws. Experience with bentonite slurries has not been promising because bentonite does not provide a tight barrier unless it is completely hydrated, and hydration is difficult to achieve in the temperatures needed to keep the wall intact. Long-term performance data on the integrity of synthetic liners installed in a trench in the wall are unavailable.

Evaluation of liners is continuing. Some North Slope operators are pursuing the feasibility of this option as an alternative to fluid management.

Excavated Pits. Lateral migration is not a concern with below-grade pits because impermeable permafrost "lines" the sides of the unit. However, this type of pit is generally not used in the Arctic for economic reasons.

Steel Tanks. Heated steel tanks could be used for mud storage prior to disposal via annular injection, with smaller reserve pits used to dispose of the cuttings. Daily trucking of mud from tanks to disposal facilities would be required, at the rate of 40 to 60 truckloads per well. Additional mud processing equipment and chemical treatment would also be needed to minimize both solids settling in the tank and the volume of liquid mud discharged into the reserve pit. The incremental cost of this option would be approximately $300,000 per well excluding the cost for injection wells for disposal.

2.2 PRODUCED WATERS

This section describes produced water generated in the Prudhoe Bay Unit. Produced water injected for both enhanced recovery and disposal are addressed. However, as discussed in Chapter 1, produced water used for enhanced recovery is not a solid waste.

2.2.1 Waste Generation

The Prudhoe Bay Unit began oil production in June 1977. As the field has aged, the generation rate for produced water has increased. For example, in 1986, about twice as much water (100 million barrels) was produced as in 1985. By 1990, the generation rate is expected to exceed 1 million barrels per day.

In 1986, sampling and analysis were conducted on produced water from three wells in the Western Operating Area of the Prudhoe Bay Unit. None of the samples exceeded any currently applicable RCRA limitations. As shown in Table 1, benzene was detected in quantities ranging from 4.3 to 19.0 mg/l, and toluene at levels ranging from 6.4 to 20 mg/l. EPA has proposed limitations for organics which have not been finalized. All of the samples exceeded the proposed TCLP limit for benzene (0.07 mg/l), and two of the samples exceeded the TCLP limit for toluene (14.4 mg/l).

2.2.2 Management Practices Under the Existing Regulations

In 1986, two-thirds of the produced water generated in the Prudhoe Bay Unit was used for enhanced recovery, while the remainder was injected in disposal wells. In either case, the activity was subject to the regulations under the Safe Drinking Water Act for Class II injection wells. Alaska has primacy to administer these regulations.

Alaska's Class II regulations are implemented by the Alaska Oil and Gas Conservation Commission (AOGCC). For all Class II wells, Alaska's regulations require automatic shut-in equipment and monthly reporting of pressure, volume and flow rate. For new wells, fully cemented production casing is required, as is mechanical integrity testing. For enhanced recovery wells, there are special restrictions on injection pressure and a requirement for compatibility testing. A variance is available from the casing and cementing requirements where there is no risk of fluid movement into a source of drinking water.

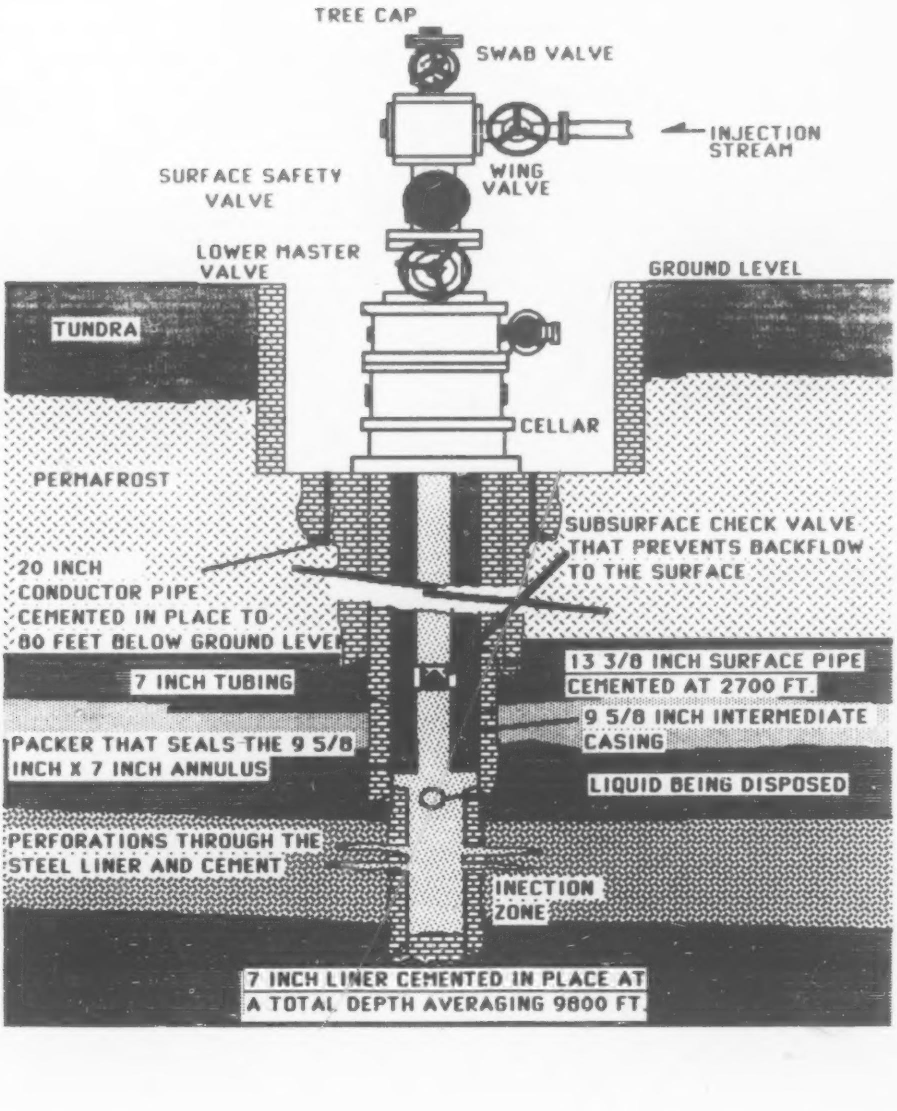
Figure 3 illustrates a typical enhanced oil recovery well on the North Slope. The figure shows surface and subsurface safety devices used to guard against spills. These devices provide for emergency shutdown in the event of excess pressure or injection line rupture. The well is also equipped with special tubing and an annular packer to control water flow. Water injection rates, temperatures and pressures are monitored 24 hours a day.

Arctic disposal wells are similarly designed, except that injection occurs at a depth of approximately 6,000 feet rather than 9,000 feet. As described in Chapter 1, the area beneath the permafrost has been exempted as an underground source of drinking water (USDW).

All tanks associated with produced water systems are enclosed, and vapor recovery systems are used to reclaim volatile hydrocarbons. Most systems use a blanket of natural gas between the surface of the water and the top of the fixed roof tank in order to prevent formation of explosive

FIGURE 3

ARCTIC ENHANCED OIL RECOVERY INJECTION WELL


TREE CAP
SWAB VALVE
INJECTION STREAM
SURFACE SAFETY VALVE
WING VALVE
LOWER MASTER VALVE
GROUND LEVEL
TUNDRA
CELLAR
PERMAFROST
SUBSURFACE CHECK VALVE THAT PREVENTS BACKFLOW TO THE SURFACE
20 INCH CONDUCTOR PIPE CEMENTED IN PLACE TO 80 FEET BELOW GROUND LEVEL
13 3/8 INCH SURFACE PIPE CEMENTED AT 2700 FT.
7 INCH TUBING
9 5/8 INCH INTERMEDIATE CASING
PACKER THAT SEALS THE 9 5/8 INCH X 7 INCH ANNULUS
LIQUID BEING DISPOSED
PERFORATIONS THROUGH THE STEEL LINER AND CEMENT
INECTION ZONE
7 INCH LINER CEMENTED IN PLACE AT A TOTAL DEPTH AVERAGING 9800 FT.

mixtures. The tanks are continuously monitored for leaks and are equipped with spill control devices. All piping is above ground.

2.2.3 Alternative Waste Management Practices

The absence of a USDW in the production area of the Prudhoe Bay Unit makes injection of produced water a very low-risk management practice. Compliance with the regulations for Class I wells is technically feasible but would entail significant costs without much environmental benefit. The Class I regulations, and their attendant costs, were reviewed previously in the sections of this report on wastes generated in the lower 48 states.

Another management option for produced water is to treat the water to meet the water quality standards and discharge it to surface waters. The treatment system would likely involve (1) reverse osmosis, (2) dissolved air flotation for oil and grease removal, (3) air stripping/distillation or charcoal treatment for volatile organics and ammonia, and (4) pH adjustment. New gravel pads and roads would be required to build the treatment plant. In addition, it is questionable whether current water treatment technology would be applicable to treating volumes of this magnitude.

2.3 ASSOCIATED WASTES

2.3.1 Waste Generation

In 1985, approximately 300,000 barrels of wastes "uniquely associated with the production of oil and gas" were generated in the Prudhoe Bay Unit. Table 2 lists these wastes and indicates how they are currently managed.

Aqueous wastes (e.g., rig washdown water and produced water tank bottoms) are typically disposed of in reserve pits or injected in Class II wells. The low oil and grease content of reserve pit fluids (see Section 2.1.1) demonstrates that oily wastes are rarely disposed of in the reserve pits.

TABLE 2
ASSOCIATED WASTES

WASTE STREAM	HANDLING PRACTICE
Rig washdown water	Reserve pit
Pigging trap solids	Recycle through production stream
Waste lubricating oils, hydraulic fluids from drilling equipment (non-RCRA hazardous)	Recycle through production stream
Waste crude oil (liquids)	Recycle through production stream
Waste solvents (non-RCRA hazardous)	Recycle through dirty water production system--Class II disposal
Untreated emulsions	Class II disposal
Cooling waters, engine waters, wastewaters	Class II disposal
Workover fluids (spent acid rinsates, wastewaters)	Reserve pit
Bottoms from dirty water tanks	Class II disposal
Oily debris (sorbents, rags)	North Slope Borough solid waste incinerator
Oily gravel, dirt (from spill cleanup)	North Slope Borough landfill

Oily wastes are reintroduced into the production process to the maximum extent possible. Oily debris is incinerated at a municipal incinerator, and oily dirt and gravel are disposed of in a municipal landfill in the permafrost.

2.3.2 Alternative Management Practices

The alternative management practices discussed earlier (e.g., Class I injection wells, lined reserve pits) could be applied to associated wastes. Another possible option not yet discussed for the Arctic is incineration of associated wastes at a RCRA Subtitle C facility.

The costs to transport wastes from the North Slope average $150 to $350 per drum, depending on the destination in the lower 48 states. Thus, if incineration were required, a incinerator would likely be built on the North Slope.

The capital costs to build a fluidized bed incinerator in the Arctic with a capacity of 2,000 pounds per hour is about $16 million (Ad Hoc Task Group, 1986). This estimate includes the costs of manufacturing the facility in modules, shipping from the manufacturer's location, assembly, site preparation (pad construction), and installation of tanks and associated units. Annual operating costs are estimated to be about $5 million.

CHAPTER 3 RISK ASSESSMENT

Previous chapters demonstrate that the climate, hydrogeology, and practices for managing petroleum waste on the North Slope differ substantially from the rest of the United States. These differences significantly affect the magnitude of the risk to human health and the environment posed by petroleum waste. This chapter addresses the risks from petroleum waste in the Arctic. First, it identifies those waste management units from which releases of hazardous constituents could occur in sufficient concentrations to pose a threat to human health and the environment. It then assesses qualitatively the extent and magnitude of the risk posed by these releases. Finally, a methodology to quantify this risk is presented.

3.1 PETROLEUM WASTES OF POTENTIAL REGULATORY CONCERN

This chapter examines only petroleum waste management practices that pose a significant threat to human health and the environment. A management practice poses a significant threat if either human or environmental (vegetation) receptors can be exposed to hazardous waste constituents in concentrations that cause adverse effects. Exposure, in turn, requires that the waste management unit release hazardous constituents and that a pathway exists for the constituents to reach a receptor.

This section examines whether humans or environmental receptors are likely to be exposed to harmful levels of hazardous constituents from the three categories of petroleum waste generated on the North Slope: (1) produced water, (2) reserve pit wastes, and (3) associated wastes. For each category, the waste's hazardous constituents, their potential for release from a waste management unit, the pathway for release, and the receptors likely to be exposed to the constituents are identified. Significant "source-pathway-receptors" are then examined in detail in the following sections of this chapter.

3.1.1 Produced Water

Produced water exhibits the proposed toxicity characteristic for benzene and toluene. While produced water is stored in tanks prior to injection, the two potential pathways for exposure are air and surface water. Air emissions are not significant because produced water tanks are equipped with vapor recovery units. Releases to surface water are unlikely because facility design incorporates spill control features.

Produced water is injected in Class II wells. The traditional pathways of concern for wastes injected underground are ground water and surface water. Exposure to ground water is unlikely in the Arctic because the ground water there has been determined to not be economically recoverable. Releases to surface water would be minimal because arctic injection wells are equipped with surface and subsurface spill control devices (see Figure 3).

Thus, neither humans nor environmental receptors are likely to be exposed to harmful quantities of hazardous constituents from produced water in the Arctic.

3.1.2 Reserve Pit Wastes

Fluids. Reserve pit fluids do not exhibit any hazardous waste characteristic, including the proposed toxicity characteristic using the TCLP. However, these fluids do generally exceed Alaska's Water Quality Standards for COD, barium, chromium and manganese.

Air is not a pathway of concern for reserve pit fluids because they contain no measurable volatile components. Again, exposure to ground water is unlikely for lack of a USDW. Surface water is a potential pathway of concern, and the primary source of release is seepage through the reserve pit wall. Exposure to humans or aquatic organisms would be minimal because reserve pits cannot be located closer than 100 feet to the ordinary high water mark of adjacent lakes and streams. However, tundra within the 100-foot zone could be adversely affected.

A secondary source of release to surface water from reserve pit fluids is through a breach in the reserve pit wall. Wall failures in the past have been due to excess fluid levels in the pit. The "fluid management" aspect of ADEC's proposed regulations should substantially reduce the risk of a breach. Thus, seepage through the reserve pit wall to surface water is the more significant pathway of concern.

Solids. Reserve pit solids do not exhibit any of the hazardous waste characteristics. They do contain measurable quantities of ethylbenzene and toluene; however, the overlying reserve pit fluids should minimize emissions of these compounds. Ground water is not a likely exposure pathway due to the absence of a USDW. A release to surface water is unlikely because the solids are frozen most of the year and are too immobile to seep through the reserve pit wall. Thus, exposure to hazardous constituents from reserve pit solids is unlikely under any scenario.

3.1.3 Associated Wastes

For wastes disposed of in injection wells, exposure is unlikely for the same reasons given above for produced water. For wastes that are landfilled, significant releases should not occur because the landfill is a subsurface excavation in permafrost. For wastes sent to the municipal incinerator, emission of hazardous constituents to the air may occur, though given the quantities involved, probably not at significant concentrations. Lastly, for the aqueous wastes disposed of in reserve pits, their net contribution to the seepage problem described above should be minimal.

3.2 QUALITATIVE RISK ASSESSMENT

As described above, the significant "source-pathway-receptor" of potential concern from arctic petroleum operations is seepage of reserve pit fluids through the reserve pit wall onto the tundra. This section reviews available literature to qualitatively assess the extent and magnitude of this potential risk.

Based on the literature, the major constituent of concern regarding impacts to the environment is the salt content which is reflected by measuring total dissolved solids (TDS). This is the one constituent most likely to be encountered at concentrations known to be damaging or potentially-damaging to tundra vegetation species. Numerous investigators have documented that the major constituent of concern to the environment in drilling fluids is the total dissolved solids (TDS) content, not chromium (or other heavy metals) or organics (diesel fuel) (Myers and Barker 1984, Younkin and Strosher 1980, Smith and James 1980).

Myers and Barker (1984) investigated areas of arctic tundra subjected to controlled discharges of reserve pit fluids in 1982 and 1983. They found that the single most important parameter to determine the vegetation impact from reserve pit fluids is the salt content. These findings support the conclusions of Younkin and Strosher (1980), who state that "high salt content [is] the cause of over 90% of the observed damage. Injury to plants result[s] from contact at the time of the spill by uptake of toxic concentrations." And again, in a study of six sites drilled in the Canadian Arctic between 1973 and 1976, Smith and James (1980) determined that "[c]hloride had the greatest plant toxicity potential of all the ions measured."

Based on these and other studies, the TDS level in reserve pit fluids below which adverse impacts to vegetation are unlikely is between 2,000 and 4,000 mg/l. Myers and Barker (1984) found this to be the case in their two-year field study. Similarly, Younkin and Strosher (1980) determined in their laboratory studies that damage to vegetation could be expected to begin at total salt levels between 4,000 and 8,000 mg/l. At concentrations less than 2,000 mg/l, no adverse effects have been demonstrated, even for the most salt-sensitive species (Myers and Barker 1984).

TDS levels were not analyzed for in the sampling program described in Chapter 2. The next section, however, provides data on TDS levels from recent studies indicating that TDS in reserve pit fluids generally fall below 2,000 mg/l.

Several factors explain why substantial damage to vegetation in the Arctic from reserve pit fluids has not been found:

1. Annual Flushing. At breakup on the North Slope, water drains by sheetflows across the tundra surface. This annual flushing substantially enhances the ability of the tundra environment to adapt or recover from reserve pit discharges. As noted by Younkin and Strosher (1980), "The results of [our] penetration studies indicate that the majority of components from sump fluids applied to topsoil systems are readily removed from the vegetation zone and should cause minimal longterm damage there."

Experiments conducted in the field demonstrate the importance of the flushing mechanism. Simmons et al. (1983) flooded a wet tundra experimental site in the Prudhoe Bay Field with seawater containing greater than 29,000 mg/l. Conductivity levels of the tundra returned to prespill levels within 30 days. Near-surface and subsurface soils were found to be completely flushed at the wet sites and were only mildly affected by the spill. This was "attributed to dilution of the soil water and to the predominance of graminoid vegetation" (characteristic of wet tundra areas).

2. Soil Saturation. Most spills onto tundra tend to collect in areas of low relief. Standing water tends to accumulate in these areas and provide a buffer between any oily components and plant roots, with only the upper leafy portions of the tundra being affected. For spilled brines, dilution from standing water is the primary mitigative mechanism (Simmons et al. 1983, Barker 1985, McKendrick 1986).

3. Resiliency of Arctic Flora and Fauna. Species that exist in the Arctic do so because they have adapted to the extremes in environmental conditions that occur there. These adaptive mechanisms make populations resilient to perturbations. Based on an assessment of the impacts to vegetation from 17 abandoned well sites in NPRA, McKendrick (1986) concluded that "there is a plasticity in the Alaskan tundra flora and

fauna which provides a capacity for adapting to several commonly occurring disturbances associated with hydrocarbon exploration."

At worst, the acreage adversely affected by reserve pit fluids should be limited to a 50-foot corridor surrounding the reserve pit -- assuming the State of Alaska promulgates its proposed standard requiring compliance with the water quality standards within 50 feet of the exterior toe of the reserve pit wall. Using a typical North Slope well production pad as an example, the work pad and reserve pit together occupy about 30 acres. A 50-foot worst-case impact zone along the reserve pit wall would add less than 2.5 acres to the overall footprint of the production pad. But, regardless of the affected acreage, as demonstrated above, any adverse effects to vegetation from reserve pit fluids are expected to be minimal and short-lived.

3.3 QUANTITATIVE RISK ASSESSMENT

This section presents a simple quantitative approach for assessing the effects of reserve pit fluids on vegetation in the Arctic. Due to a sparsity of field data, numerous conservative assumptions have been made. Presented below is a description of the model, the model assumptions, and available input data. Also included is a brief discussion of other modeling approaches that were considered but rejected.

3.3.1 Possible Modeling Approach

To develop a simple quantitative model of the reserve pit system, the transport of liquids through two different environments, the reserve pit wall and the tundra must be considered. The model described below operates in two steps:

Step 1: Transfer Through the Wall. Transport of reserve pit liquid through the pit wall is modeled as saturated flow through a porous media. The reserve pit wall is simulated by using the Dupuit's solution to the

LaPlace equation for an unconfined aquifer (Todd, 1980). The assumptions used in modeling fluid transport through the reserve pit wall are:

- Flow occurs only during that percentage of the year equal to the thaw period,
- Flow is horizontal and uniform everywhere in the vertical section,
- Flow is undirectional in the direction perpendicular to the reserve pit wall since the reserve pit walls are very long with respect to the width of pit wail, and
- Reserve pit liquid height is constant over the thaw period.

Using the above assumptions, the flow, Q_w, exiting a unit length section of the reserve pit wall can be calculated using Dupuit's solution to LaPlace's equation:

$$Q_w = \frac{KL}{2X} (H_o^2 - H^2)$$

where Q_w = flow out of the reserve pit wall section (m^3/day)
K = hydraulic conductivity (m/day)
X = average width of the reserve pit wall (m)
H_o = Assumed height (m) of reserve pit liquids
H = height of tundra water (m)
L = unit length of reserve pit wall (m)

Step 2: Transport Across the Tundra. Once the flow exiting the toe of the reserve pit wall section is calculated, the next step in the model simulates movement of the water across an adjacent section of tundra. The tundra is modeled using a one-dimensional conservative case river water quality model (Thomann, 1972).

The assumptions used to model fluid transport across the tundra are:

- The contaminant of concern is a conservative species;
- Steady-state flow conditions exist during the thaw period;
- Reserve pit seepage is the only flow component in the tundra;

- Seasonal thaw of reserve pit and tundra are not simultaneous;
- Complete mixing of tundra waters occurs on a daily basis within a volume defined by a unit width, a liquid height in the tundra, and the average distance the water travels on the tundra;
- There is no resistance to flow caused by the tundra; and
- Modeling of a section of tundra of unit width is representative of the tundra transport occurring along the length of the reserve pit wall.

With the above assumptions, the concentration of the conservative species, C, can be calculated at any given distance from the reserve pit wall section with the following equation:

$$C = \frac{M_{in} + M_{am}}{(2{,}000)(Q_w)}$$

where C = Concentration of a conservative species in a tundra section of width L, a given distance from the reserve pit wall (mg/l)

M_{in} = Mass of conservative species per unit time of the toe of the reserve pit wall expressed as initial concentration times Q_w (mg/day)

M_{am} = Mass of conservative species per unit time in the ambient tundra water expressed as ambient concentration times volume of tundra water per unit time (mg/day)

Q_w = Flow exiting reserve pit wall section (m^3/day)

Liquid Transport Profile. With the above equations and assumptions, a profile of the liquid transport during the thaw period can be determined with a finite difference model. This is accomplished by sequentially calculating the concentration of a conservative species in a volume of tundra water of unit width and a length that is dependent on the velocity of the waters going outward from the pit wall.

Yearly, an influx of fresh water from snow melt would create a one-time dilution of tundra concentrations. This influx would be equal to the annual precipitation and occurs prior to any pit release during the year.

If spring thaw and seepage are sequentially modeled, a several-year impact can be evaluated. Translation from a unit width impact to an overall impact of a reserve pit is accomplished by considering the concentration profile calculated for the tundra section and multiplying by the length of the reserve pit wall. The effect of snow melt dilution is likely to be underestimated by this approach since snow drifting near the edges of the reserve pit walls will provide additional dilution water that is not accounted for.

To model a closed reserve pit, it should be assumed that the fluids would be removed from the pit prior to capping the solids with gravel. Fluid seepage from a closed pit should be minimal because the closed site will be windswept and thus kept dry.

Available Data. Data available to run the simple quantitative model is presented below.

1. Waste Composition

   Based on the literature reviewed earlier, TDS is the pollutant of potential concern. Data other than that referred to in Chapter 2 should be used since that data does not include TDS. Useful data are reported in a study on tundra water discharge which includes conductivity data (Enderle and Marrs 1982). A factor of 0.72, developed by Myers and Barker (1984) was used to convert conductivity data from Marrs and Enderle to TDS. The estimated reserve pit data collected by Marrs and Enderle is shown below.

Well Pad	Time Preceding the Sampling Since the Last Discharge (Yrs)	Estimated TDS, mg/l
X_n, H_s, C_{nw}	0	4,710
J_n, D_c, B_s	1	1,970
J_s, D_n, B_n	2+	1,810

   where X_n denotes X pad, north pit

2. Average Height of Reserve Pit Solids

   1.7 feet

3. Height of Liquids Above the Reserve Pit Solids

   1 to 3 feet

4. Conductivity of Reserve Pit Wall Material

   A hydraulic conductivity for the construction material (sandy gravel) of 0.005 cm/sec is assumed based on a typical conductivity of 0.01 cm/s for this material (Sowers 1970) and a small reduction in conductivity due to mud particulate accumulation which is assumed to occur in the gravel during discharge of muds to the pit.

5. Reserve Pit Geometry

   A typical worst-case reserve pit wall would measure approximately 25 feet at the crown, with a 2 to 1 side slope and a height of 5 feet. A typical length of a worst case reserve pit wall is approximately 1,000 feet.

6. Weather

   Based on the data provided in Appendix B, the annual rainfall is approximately 13 cm or 5 inches at Prudhoe Bay, Alaska. Annual temperature data, presented in the appendix, indicate that the number of thaw days is approximately 105 days per year.

3.3.2 Modeling Options Considered but Rejected

The following approaches were considered, but rejected, for modeling the risks to arctic vegetation from reserve pit fluids.

Tundra Transport as Groundwater Approach. This approach is similar to the model just described. However, when the reserve pit discharge enters the tundra, a more complex approach to tundra transport is provided. This method would use a nonlinear ground water flow model which accounts for periodic freezing and thawing as well as unsaturated conditions with two distinct phases of transport. One phase would simulate flow on the tundra and another simulates ground water flow through the tundra. This would involve replacing the nonlinear unsaturated hydraulic conductivity term in the ground water model with a nonlinear resistance-to-flow term to better simulate surface water flow. Such a modeling effort would require a great deal of data which is presently not available.

Mass Balance Approach. A mass balance approach to fluid transport through the reserve pit wall was considered as a means of estimating annual seepage. After further investigation, this approach was deemed infeasible due to lack of accurate data on early-season and late-season water levels in reserve pits. Although such estimates are available, the data is not based on surveyed elevation information, nor were the spring and fall water-level observations necessarily recorded at the same location in each pit. A six-inch discrepancy in the water level of a typical 1,000 foot by 300 foot reserve pit can account for approximately 1 million gallons of water. Thus, seepage rates estimated by mass balance would be highly inaccurate with the available data. Evaporation and rainfall rates would also require consideration. Additionally, the mass balance approach does not attempt to predict fluid transport across the tundra.

3.4 CONCLUSION

One generally resorts to quantitative models because empirical data on risk is unavailable. This is not the case here. The literature demonstrates that reserve pit fluids have a minimal impact on tundra and that the impact is quickly reversible. Furthermore, assuming Alaska promulgates the performance standard in its proposed rules, any adverse impact to arctic vegetation will be confined to a 50-foot corridor around the reserve pit wall.

The numeric models described in this chapter have not undergone peer review, nor is sufficient sampling data available to validate them. Given the existence of real-world data and the uncertain validity of the models outlined here, it is appropriate to rely on the the existing literature to assess the risks to arctic vegetation from reserve pit fluids.

APPENDIX A
WASTE COMPOSITION DATA

TABLE A-1

CONVENTIONAL PARAMETERS - PIT WATERS

	pH	TSS mg/l	Cl mg/l	NO_3 mg/l	BOD mg/l	COD mg/l	TOC mg/l	NH_4 mg/l	O&G mg/l	CN mg/l
A Pad	8.02	250	1960	ND	4	250	218	0.2	ND	0.01
U Pad	7.99	32	2650	0.1	9	260	362	ND	1.9	ND
S Pad	8.53	532	4360	0.2	9	390	268	0.6	0.6	ND
G Pad	8.18	4900	810	ND	37	140	31	0.2	3.5	ND
Average	8.18	1429	2445	0.08	15	260	220	0.3	1.5	<0.01

BOD = Biochemical Oxygen Demand
Cl = Chloride
CN = Cyanide
COD = Chemical Oxygen Demand
NH_4 = Ammonia as N
ND = Not Detected (No response on instrument)
NO_3 = Nitrate and Nitrite as N
O&G = Oil and Grease
TSS = Total Suspended Solids

TABLE A-2
PIT WATER METALS ANALYSES (mg/l)
Detection Limits in Parentheses; ND = Not Detected*

TOTAL METALS	A PAD PIT WATER		U PAD PIT WATER		S PAD PIT WATER		G PAD PIT WATER	
Aluminum	5.0	(0.25)	0.38	(0.25)	7.5	(0.25)	18	(0.5)
Antimony	ND	(0.25)	ND	(0.25)	ND	(0.25)	ND	(0.5)
Arsenic	0.006	(0.002)	0.008	(0.002)	0.016	(0.002)	0.004	(0.002)
Barium	3.8	(0.025)	0.29	(0.025)	4.4	(0.025)	3.9	(0.05)
Beryllium	ND	(0.005)	ND	(0.005)	ND	(0.005)	0.01	(0.01)
Boron	0.3	(0.25)	0.3	(0.25)	3.6	(0.25)	1.5	(0.04)
Cadmium	ND	(1)	ND	(1)	ND	(1)	ND	(0.04)
Calcium	73	(1)	52	(1)	42	(1)	120	(1)
Chromium	0.45	(0.025)	0.11	(0.025)	0.22	(0.025)	0.53	(0.05)
Cobalt	ND	(0.015)	ND	(0.015)	ND	(0.015)	0.06	(0.03)
Copper	ND	(0.05)	ND	(0.05)	ND	(0.05)	0.12	(0.03)
Iron	11	(0.25)	1.6	(0.25)	9.8	(0.2)	140	(0.5)
Lead	ND	(0.1)	ND	(0.1)	ND	(0.1)	ND	(0.2)
Magnesium	10	(0.5)	5.1	(0.5)	6.7	(0.5)	30	(1)
Manganese	0.31	(0.025)	0.30	(0.025)	0.18	(0.025)	2.2	(0.05)
Mercury	ND	(0.0001)	ND	(0.0001)	ND	(0.0001)	0.0004	(0.0001)
Molybdenum	0.077	(0.025)	0.085	(0.025)	0.078	(0.025)	ND	(0.05)
Nickel	ND	(0.05)	ND	(0.05)	0.06	(0.05)	0.2	(0.01)
Phosphorus(P)	0.3	(0.3)	ND	(0.3)	0.5	(0.3)	4	(0.6)
Potassium	13	(1.5)	9.0	(1.5)	6.2	(1.5)	18	(3)
Selenium	ND	(0.04)	ND	(0.02)	ND	(0.04)	ND	(0.004)
Silver	ND	(0.015)	ND	(0.015)	ND	(0.015)	ND	(0.03)
Sodium	2200	(2.5)	2900	(2.5)	2100	(2.5)	680	(5)
Strontium	0.86	(0.025)	0.56	(0.025)	0.30	(0.025)	0.84	(0.05)
Thallium	ND	(0.02)	ND	(0.04)	ND	(0.04)	ND	(0.004)
Tin	ND	(0.15)	ND	(0.15)	ND	(0.15)	ND	(0.3)
Titanium	0.090	(0.01)	0.02	(0.01)	0.088	(0.01)	0.12	(0.02)
Vanadium	0.02	(0.01)	ND	(0.01)	0.02	(0.01)	0.16	(0.02)
Zinc	0.21	(0.05)	0.07	(0.05)	0.18	(0.05)	1.1	(0.04)

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* Detection limits may vary with the standard used and instrument sensitivity. "ND" means there was no response of the instrument.

TABLE A-3

GC/MS ANALYSIS RESULTS* - PIT WATERS

	VOLATILE ORGANICS	BASE/NEUTRAL ORGANICS	ACID ORGANICS
A Pad	BDL for all compounds	Bis(2-ethylhexyl) phthalate - 0.065 mg/l	BDL for all compounds
U Pad	BDL for all compounds	BDL for all compounds	BDL for all compounds
S Pad	BDL for all compounds	C10 to C14 - 0.087 mg/l	BDL for all compounds
G Pad	BDL for all compounds	C10 to C30 - 0.15 mg/l Fluorene - 0.001 mg/l Naphthalene - 0.005 mg/l Phenanthrene - 0.001 mg/l	BDL for all compounds

* = Only compounds with value above detection limits are reported

BDL = Below Detection Limit (Weak response of instrument below the threshold for detection)

TABLE A-4

CONVENTIONAL PARAMETERS - PIT SOLIDS

	pH	Cl, mg/l	% TOC	% OIL	% WATER	% SOLIDS
S Pad	10.76	1550	1.8	1.1	58.7	40.2
U Pad	10.14	1280	1.1	1.7	51.6	46.7
U Pad Dup	10.15	1510	1.3	2.2	50.6	47.2
A Pad	9.96	1640	0.56	2.3	62.1	35.6
G Pad	10.52	550	1.2	ND	45.0	55.0
F Pad	9.98	186	1.4	ND	36.0	64.0
Average	10.25	1119	1.2	1.2	50.7	48.1

ND = None Detected (No response on instrument)

TABLE A-5
PIT SOLID METALS ANALYSES (mg/kg)
Detection Limits in Parentheses; ND = Not Detected*

TOTAL METALS	S PAD SOLIDS		U PAD SOLIDS		U PAD SOLIDS DUP		A PAD SOLIDS	
Aluminum	2300	(10)	3300	(10)	3000	(10)	2200	(10)
Antimony	ND	(5)	ND	(5)	ND	(5)	ND	(5)
Arsenic	5.0	(0.4)	3.6	(0.2)	5.2	(0.4)	4.0	(0.4)
Barium	3500	(0.5)	2800	(0.5)	2600	(0.5)	3200	(0.5)
Beryllium	0.2	(0.1)	0.28	(0.1)	0.26	(0.1)	0.2	(0.1)
Boron	4	(4)	ND	(4)	ND	(4)	ND	(4)
Cadmium	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Calcium	6500	(150)	6900	(150)	7800	(150)	5700	(150)
Chromium	32	(0.5)	51	(0.5)	76	(0.5)	56	(0.5)
Cobalt	4.1	(0.3)	5.0	(0.3)	5.2	(0.3)	3.3	(0.3)
Copper	9.3	(1)	11	(1)	12	(1)	8.0	(1)
Iron	9800	(10)	11300	(10)	12000	(10)	7900	(10)
Lead	27	(2)	36	(2)	36	(2)	24	(2)
Magnesium	1700	(10)	1900	(10)	1900	(10)	1400	(10)
Manganese	120	(0.5)	150	(0.5)	150	(0.5)	100	(0.5)
Mercury	ND	(0.05)	ND	(0.05)	ND	(0.05)	ND	(0.05)
Molybdenum	23	(0.5)	27	(0.5)	29	(0.5)	19	(0.5)
Nickel	31	(1)	14	(1)	15	(1)	10	(1)
Phosphorus	230	(6)	240	(6)	260	(6)	190	(6)
Potassium	640	(30)	730	(30)	740	(30)	560	(30)
Selenium	ND	(2)	ND	(2)	ND	(1)	ND	(1)
Silver	ND	(0.3)	ND	(0.3)	ND	(0.3)	ND	(0.3)
Sodium	2200	(100)	2300	(100)	2500	(100)	2200	(100)
Strontium	24	(0.5)	27	(0.5)	31	(0.5)	26	(0.5)
Thallium	ND	(0.2)	ND	(0.2)	ND	(0.2)	ND	(0.2)
Tin	ND	(15)	ND	(15)	ND	(15)	ND	(15)
Titanium	31	(1)	39	(1)	54	(1)	33	(1)
Vanadium	9.0	(0.2)	11	(0.2)	11	(0.2)	7.5	(0.2)
Zinc	73	(2)	82	(2)	95	(2)	57	(2)

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* Detection limits may vary with the standard used and instrument sensitivity. "ND" means there was no response of the instrument.

TABLE A-5 (Cont'd)
PIT SOLIDS METALS ANALYSES (mg/kg)
Detection Limits in Parentheses; ND = Not Detected*

TOTAL METALS	G PAD SOLIDS		F PAD RIG MUD	
Aluminum	3400	(10)	2800	(10)
Antimony	ND	(5)	ND	(5)
Arsenic	7.3	(0.2)	8.2	(0.2)
Barium	3400	(3)	1500	(0.5)
Beryllium	ND	(0.5)	0.4	(0.1)
Boron	10	(2)	ND	(6)
Cadmium	0.6	(0.5)	0.8	(0.5)
Calcium	9500	(50)	8000	(150)
Chromium	35	(0.5)	25	(0.5)
Cobalt	5.0	(0.3)	0.6	(0.3)
Copper	15	(1)	16	(2)
Iron	13300	(5)	27000	(5)
Lead	74	(2)	46	(2)
Magnesium	2700	(10)	5200	(10)
Manganese	120	(1)	320	(0.5)
Mercury	0.10	(0.05)	ND	(0.05)
Molybdenum	ND	(0.5)	64	(0.5)
Nickel	16	(1)	25	(1)
Phosphorus	310	(6)	320	(6)
Potassium	750	(30)	1500	(30)
Selenium	ND	(4)	ND	(8)
Silver	ND	(0.3)	ND	(0.3)
Sodium	1400	(50)	1000	(200)
Strontium	95	(0.5)	22	(1)
Thallium	ND	(0.2)	ND	(2)
Tin	ND	(10)	ND	(3)
Titanium	30	(1)	43	(0.2)
Vanadium	15	(0.2)	20	(0.2)
Zinc	180	(4)	76	(4)

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* Detection limits may vary with the standard used and instrument sensitivity. "ND" means there was no response of the instrument.

TABLE A-6

GC/MS ANALYSIS RESULTS* - PIT SOLIDS

	VOLATILE ORGANICS	BASE/NEUTRAL ORGANICS	ACID ORGANICS
S Pad	Ethylbenzene - 9.0 mg/kg Toluene - 4.4 mg/kg	Biphenol - 4.10 mg/kg C10 to C30 - 344.7 mg/kg p-Cymene - 4.9 mg/kg Fluorene - 1.4 mg/kg Naphthalene - 9.8 mg/kg	BDL for all compounds
U Pad	Ethylbenzene - 8.8 mg/kg Toluene - 4.7 mg/kg	Biphenol - 4.9 mg/kg C10 to C30 - 435.9 mg/kg p-Cymene - 8.3 mg/kg Fluorene - 1.8 mg/kg Naphthalene - 13.0 mg/kg	BDL for all compounds
U Pad Dup	Ethylbenzene - 8.9 mg/kg Toluene - 4.9 mg/kg	Biphenol - 5.1 mg/kg C10 to C30 - 479.7 mg/kg p-Cymene - 7.7 mg/kg Fluorene - 1.5 mg/kg Naphthalene - 13.0 mg/kg	BDL for all compounds
A Pad	Ethylbenzene - 3.5 mg/kg Toluene - 0.54 mg/kg	Biphenol - 3.3 mg/kg C10 to C30 - 301.1 mg/kg p-Cymene - 2.8 mg/kg Fluorene - 7.8 mg/kg Naphthalene - 6.8 mg/kg Phenanthrene - 8.8 mg/kg	BDL for all compounds
G Pad	Ethylbenzene - 4.1 mg/kg Toluene - 3.0 mg/kg	Biphenol - 1.8 mg/kg C10 to C30 - 192.8 mg/kg p-Cymene - 1.9 mg/kg Fluorene - 0.06 mg/kg Naphthalene - 5.5 mg/kg Phenanthrene - 0.95 mg/kg	BDL for all compounds
F Pad	Benzene - 0.06 mg/kg Ethylbenzene - 1.2 mg/kg Toluene - 1.0 mg/kg	C10 to C30 - 40.4 mg/kg Naphthalene - 1.5 mg/kg	BDL for all compounds

* = Only compounds with values above detection limits are reported

BDL = Below Detection Limit (Weak response of instrument below the threshold for detection)

TABLE A-7

CONVENTIONAL PARAMETERS - PRODUCED WATERS

	pH	TSS mg/l	Cl mg/l	NO_3 mg/l	BOD mg/l	COD mg/l	TOC mg/l	NH_4 mg/l	O&G mg/l	CN mg/l
GC 1	6.91	24	9000	ND	705	1430	293	24	252	0.01
GC 1 Dup	6.89	19	12300	ND	535	955	357	23	247	ND
GC 2	6.93	92	12000	ND	290	490	120	21	34	ND
GC 3	7.12	29	10800	ND	390	810	359	23	256	ND
Average	6.96	41	11025	ND	480	921	282	23	197	<0.01

BOD = Biochemical Oxygen Demand

Cl = Chloride

CN = Cyanide

COD = Chemical Oxygen Demand

NH_4 = Ammonia as N

ND = Not detected (No response on instrument)

NO_3 = Nitrate and Nitrite as N

O&G = Oil and Grease

TSS = Total Suspended Solids

TABLE A-8
PRODUCED WATER METALS ANALYSES (mg/l)
Detection Limits in Parentheses; ND = Not Detected*

TOTAL METALS	GC 1		GC 1 DUP		GC 2		GC 3	
Aluminum	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Antimony	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Arsenic	ND	(0.004)	ND	(0.01)	ND	(0.02)	0.017	(0.002)
Barium	3.0	(0.05)	3.0	(0.05)	0.61	(0.05)	3.8	(0.05)
Beryllium	ND	(0.01)	ND	(0.01)	ND	(0.02)	ND	(0.01)
Boron	130	(0.5)	130	(0.5)	110	(0.04)	140	(0.5)
Cadmium	ND	(0.04)	ND	(2)	ND	(0.04)	ND	(2)
Calcium	260	(2)	250	(2)	220	(1)	170	(2)
Chromium	ND	(0.05)	ND	(0.05)	ND	(0.05)	ND	(0.05)
Cobalt	ND	(0.03)	ND	(0.03)	ND	(0.03)	ND	(0.03)
Copper	ND	(0.1)	ND	(0.1)	ND	(0.03)	ND	(0.1)
Iron	5.7	(0.5)	5.6	(0.5)	6.3	(0.5)	3.2	(0.5)
Lead	ND	(0.2)	ND	(0.2)	ND	(0.2)	ND	(0.2)
Magnesium	85	(1)	84	(1)	220	(1)	24	(1)
Manganese	ND	(0.05)	ND	(0.05)	ND	(0.05)	ND	(0.05)
Mercury	ND	(0.0001)	ND	(0.0001)	ND	(0.0002)	ND	(0.0001)
Molybdenum	ND	(0.05)	ND	(0.05)	ND	(0.05)	ND	(0.05)
Nickel	ND	(0.1)	ND	(0.1)	ND	(0.1)	ND	(0.1)
Phosphorus	1.3	(0.6)	1.2	(0.6)	ND	(0.6)	1	(0.6)
Potassium	73	(3)	74	(3)	100	(3)	68	(3)
Selenium	ND	(0.08)	ND	(0.08)	ND	(0.2)	ND	(0.08)
Silver	ND	(0.03)	ND	(0.03)	ND	(0.03)	ND	(0.03)
Sodium	8500	(5)	8500	(5)	7700	(5)	8700	(5)
Strontium	30	(0.05)	29	(0.05)	23	(0.05)	22	(0.05)
Thallium	ND	(0.08)	ND	(0.08)	ND	(0.04)	ND	(0.1)
Tin	ND	(0.3)	ND	(0.3)	ND	(0.3)	ND	(0.3)
Titanium	ND	(0.02)	ND	(0.02)	ND	(0.02)	ND	(0.02)
Vanadium	ND	(0.02)	ND	(0.02)	ND	(0.02)	ND	(0.02)
Zinc	0.1	(0.1)	0.1	(0.1)	0.07	(0.04)	0.1	(0.1)

* Detection limits may vary with the standard used and instrument sensitivity. "ND" means there was no response of the instrument.

TABLE A-9

GC/MS ANALYSIS RESULTS* - PRODUCED WATERS

	VOLATILE ORGANICS	BASE/NEUTRAL ORGANICS	ACID ORGANICS
GC 1	Benzene - 19.0 mg/l Ethylbenzene - 2.4 mg/l Toluene - 20.0 mg/l	C10 to C30 - 4.0 mg/l p-Cymene - 0.11 mg/l 2,4 Dimethylphenol - 0.81 mg/l Fluorene - 0.016 mg/l Naphthalene - 0.36 mg/l Phenanthrene - 0.03 mg/l Phenol - 1.4 mg/l	BDL for all compounds
GC 1 Dup	Benzene - 18.0 mg/l Ethylbenzene - 2.2 mg/l Toluene - 18.0 mg/l	C10 to C30 - 7.19 mg/l p-Cymene - 0.12 mg/l Biphenol - 0.057 mg/l 2,4 Dimethylphenol - 1.0 mg/l Fluorene - 0.017 mg/l Naphthalene - 0.35 mg/l Phenanthrene - 0.033 mg/l Phenol - 1.6 mg/l	BDL for all compounds
GC 2	Benzene - 4.3 mg/l Ethlybenzene - 0.32 mg/l Toluene - 3.3 mg/l	C10 to C30 7.70 mg/l 2,4 Dimethylphenol - 0.56 mg/l Naphthalene - 0.33 mg/l Phenanthrene - 0.021 mg/l Phenol - 1.40 mg/l	BDL for all compounds
GC 3	Benzene - 12.0 mg/l Ethylbenzene - 1.2 mg/l Toluene - 9.3 mg/l	C10 to C30 - 3.55 mg/l 2,4 Dimethylphenol - 0.90 mg/l Phenol - 1.20 mg/l	BDL for all compounds

* = Only compounds with values above detection limits are reported

BDL = Below Detection Limit (No response on instrument)

TABLE A-10

TCLP RESULTS FOR RESERVE PIT LIQUIDS AND SOLIDS

	A PAD		G PAD		S PAD		U PAD	
	LIQUID	SOLID	LIQUID	SOLID	LIQUID	SOLID	LIQUID	SOLID
Metals (mg/l)								
Ar (5.0)	ND	0.011	0.004	ND	0.016	0.006	0.008	0.003
Ba (100)	3.8	1.4	3.9	ND	4.4	0.8	0.29	0.9
Cd (1.0)	ND	ND	ND	ND	ND	ND	ND	ND
Cr (5.0)	0.45	0.26	0.53	0.081	0.22	0.069	0.11	0.11
Pb (5.0)	ND	0.10	ND	0.28	ND	ND	ND	0.05
Hg (0.2)	ND	ND	0.0004	ND	ND	ND	ND	ND
Se (1.0)	ND	ND	ND	ND	ND	ND	ND	ND
Ag (5.0)	ND	ND	ND	ND	ND	ND	ND	ND
Volatile Organics (mg/l)								
Acrylonitrile	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Benzene (0.07)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Carbon Tet.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chlorobenzene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dichloroethene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Methyl Chlor	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Meth eth Ketone	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroetha	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethe	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Toluene (14.4)	BDL	0.04	BDL	0.04	BDL	0.12	BDL	0.13
Trichloroethane	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Vinyl Chloride	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

TABLE A-10 (Cont'd)

TCLP RESULTS FOR RESERVE PIT LIQUIDS AND SOLIDS

	A PAD		G PAD		S PAD		U PAD	
	LIQUID	SOLID	LIQUID	SOLID	LIQUID	SOLID	LIQUID	SOLID
Base/Neutral Organics (mg/l)								
Bis 2-chlor eth	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Nitrobenzene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Phenol	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dichlorobenz	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dinitrotoluene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexachlorobenz	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexachlorobut	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexachloroetha	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Acid Organics (mg/l)								
Pentachlorophen	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichlorophenol	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

ND = Not Detected (No response on instrument)

BDL = Below Detection Limits (Weak response of instrument below the threshold for detection)

TABLE A-11

COMPARISON OF RESERVE PIT AND INJECTION WATER DATA TO ADEC WATER QUALITY CRITERIA*

	A PAD	G PAD	S PAD	U PAD	GC 1	GC 2	GC 3
COD (200 mg/l)*	250	140	260	390	1192	490	810
TROG (15 mg/l)	ND	3.5	1.9	0.6	250	34	256
Settleable Solids (0.2 mg/l)	NA	NA	NA	NA	NA	NA	NA
Salinity (3 ppt)	NA	NA	NA	NA	NA	NA	NA
pH (6.0 - 9.0)	8.02	8.18	7.91	8.53	6.90	6.93	7.12
As (0.05 mg/l)	0.006	0.004	0.008	0.016	ND	ND	0.017
Ba (1.00 mg/l)	3.8	3.9	0.29	4.4	3.0	0.61	3.8
Cd (0.01 mg/l)	ND	ND	ND	ND	ND	ND	ND
Cr (0.05 mg/l)	0.45	0.53	0.11	0.22	ND	ND	ND
Pb (0.05 mg/l)	ND	ND	ND	ND	ND	ND	ND
Mn (0.005 mg/l)	0.31	2.2	0.30	0.18	ND	ND	ND
Hg (0.002 mg/l)	ND	ND	ND	ND	ND	ND	ND

* = Maximum Limit Shown in Parentheses

COD = Chemical Oxygen Demand

NA = No Analysis Performed

ND = Not Detected (No response on instrument)

TROG = Total Recoverable Oil and Grease

TABLE A-12

METAL PARAMETERS

PARAMETER	METHOD (WATER)	REFERENCE (WATER)[a]	NOMINAL DETECTION LIMIT mg/l (WATER)	DRINKING WATER STANDARD (mg/l)	METHOD (SOLIDS)	REFERENCE (SOLIDS)[b]	NOMINAL DETECT. LIMIT (SOLID) mg/kg
Aluminum	ICP	200.7	0.05	—	ICP	6010	5.0
Antimony	ICP	200.7	0.05	—	ICP	6010	5.0
Arsenic	Furnace AA	206.2	0.002	0.05	Furnace	7060	0.2
Barium	ICP	200.7	0.005	1.0	ICP	6010	0.4
Beryllium	ICP	200.7	0.001	—	ICP	6010	0.2
Cadmium	ICP	200.7	0.002	0.01	ICP	6010	1.0
Chromium	ICP	200.7	0.005	0.05	ICP	6010	0.5
Copper	ICP	200.7	0.002	1.0	ICP	6010	0.4
Lead	ICP	200.7	0.025	0.05	ICP	6010	0.5
Mercury	Cold Vapor AA	245.1	0.0002	0.002	Cold Vapor AA	7471	0.04
Nickel	ICP	200.7	0.01	—	ICP	6010	0.6
Osmium	ICP	200.7	0.10	—	ICP	6010	20
Selenium	Furnace AA	270.2	0.002	0.01	Furnace AA	7740	1.0
Silver	ICP	200.7	0.005	0.05	ICP	6010	1.0
Strontium	ICP	200.7	0.005	—	ICP	6010	1.0
Thallium	ICP	200.7	0.10	—	ICP	6010	20
Vanadium	ICP	200.7	0.003	—	ICP	6010	0.6
Zinc	ICP	200.7	0.005	5	ICP	6010	1.0

[a] = EPA, 1984

[b] = EPA, 1982

TABLE A-13

DETECTION LIMITS FOR CONVENTIONAL PARAMETERS

PARAMETER	REFERENCE (WATER)	NOMINAL DETECTION LIMIT mg/l (WATER)	REFERENCE (SOLIDS)	NOMINAL DETECTION LIMIT mg/l (SOLIDS)
BOD	1-405.1; 2-507	2	--	--
COD	1-410.4; 2-508A	5	--	--
TSS	1-160.2	2	--	--
Oil/Water/Solids	--	--	--	0.1%
TOC	1-415.1; 2-505	0.1	3-29-3.2	1000
Oil & Grease	1-413.1; 2-503A	1	--	--
pH (Corrosivity)	1-150.1; 2-423	0.01 units	4-9045	0.01 units
Chloride	1-325.1; 2-407B	3	--*	--*
Reactive CN	--	--	5	0.1
Reactive Sulfide	--	--	5	0.5
Total Phenols	1-420.1; 2-510A,B	0.01	--	--
Total Cyanide	1-335.2; 2-412B,D	0.01	--	--

* Dissolved chloride can be measured by performing a deionized water leach and measuring chloride in the leachate using the water method listed.

References:

1. EPA, 1979
2. APHA, 1980
3. Page, 1982
4. EPA, 1982
5. Claussen, 1985.

APPENDIX B
METEOROLOGICAL DATA

The following tables present climatological data for the Prudhoe Bay vicinity. Table B-1 provides a nine-year temperature record for Prudhoe Bay, while Table B-2 gives precipitation, snowfall, snow cover, wind, and humidity information.

TABLE B-1

NINE-YEAR TEMPERATURE RECORD (°C), PRUDHOE BAY (ARCO AIRFIELD), ALASKA

	J	F	M	A	M	J	J	A	S	O	N	D	Yr
1970													
Avg. maximum	-24.7	-24.7	-25.5	-15.2	-3.2	5.2	8.4	7.8	-0.1	-14.7	-15.2	-22.7	-10.4
Avg. minimum	-30.5	-31.9	-32.4	-21.9	-9.6	-0.4	2.0	2.3	-4.9	-20.2	-23.7	-30.5	-16.8
Average	-27.6	-28.3	-29.0	-18.6	-6.4	2.3	5.2	5.1	-2.5	-17.4	-19.4	-26.6	-13.6
1971													
Avg. maximum	-27.4	-33.5	-24.9	-17.3	-3.7	7.4	11.5	6.1	2.3	-8.0	-16.7	-25.7	-10.8
Avg. minimum	-36.8	-40.1	-32.6	-26.8	-9.6	1.4	3.9	0.6	-1.6	-15.9	-23.2	-29.4	-17.5
Average	-32.1	-36.8	-28.7	-21.7	6.7	4.4	7.7	3.3	0.5	-11.9	-19.9	-27.6	-14.2
1972													
Avg. maximum	-26.4	-29.1	-28.2	-15.7	-2.9	4.6	10.1	9.4	0.9	-4.8	-15.7	-19.8	-9.8
Avg. minimum	-31.2	-34.8	-34.1	-24.3	-8.6	0.9	4.0	3.6	-1.2	-9.8	-19.3	-24.6	-15.1
Average	-28.8	-31.9	-31.1	-20.1	-5.8	2.7	7.1	6.5	-0.7	-7.3	-17.6	-22.0	-12.4
1973													
Avg. maximum	-24.4	-25.3	-29.5	-13.8	2.2	4.3	11.2	9.7	4.8	7.1	-15.3	-19.9	-8.9
Avg. minimum	-29.1	-30.3	-35.9	-22.3	7.1	-0.9	4.8	-4.6	0.4	1.1	-18.8	-23.8	-14.0
Average	-26.7	-27.8	-32.7	-18.0	-4.7	2.6	8.0	7.2	2.6	9.1	-17.1	-21.9	-11.4
1974													
Avg. maximum	-24.8	-34.1	-26.6	-17.0	-3.5	3.6	10.0	10.8	2.2	-12.8	-22.7	-32.9	-12.3
Avg. minimum	-29.3	-38.0	-33.9	-26.2	-9.4	-1.1	2.9	2.3	-1.4	-17.7	-27.7	-39.3	-18.2
Average	-27.1	-36.1	-30.2	-21.6	-6.4	1.2	6.5	6.6	0.4	-15.2	-25.2	-36.1	-15.3
1975													
Avg. maximum	-39.1	ND	-19.5	-14.3	-4.2	5.9	9.8	7.0	-0.5	-12.0	-24.7	-29.8	-10.4
Avg. minimum	-37.4	ND	-28.0	-24.7	-8.6	1.1	3.9	1.8	-4.6	-15.4	-27.9	-33.7	-15.8
Average	-34.7	ND	-23.7	-19.5	-6.4	-3.5	6.8	4.4	-2.5	-13.7	-26.3	-31.7	-13.1
1976													
Avg. maximum	-27.5	-27.7	-24.8	-10.9	-2.9	6.9	10.4	10.4	4.3	-6.7	-12.9	-27.1	-9.0
Avg. minimum	-34.1	-36.1	-33.2	-22.0	-8.9	-0.6	3.1	2.8	-1.0	-13.2	-20.2	-33.5	-16.4
Average	-30.8	-31.8	-29.0	-16.5	-5.9	3.2	6.8	6.6	1.6	-11.4	-16.6	-30.3	-12.7

TABLE B-1 (Cont'd)

NINE-YEAR TEMPERATURE RECORD (°C), PRUDHOE BAY (ARCO AIRFIELD), ALASKA

	J	F	M	A	M	J	J	A	S	O	N	D	Yr
1977													
Avg. maximum	-20.4	-24.4	-26.7	-13.9	-2.6	6.6	9.2	12.5	5.8	-2.6	-17.9	-19.0	-7.8
Avg. minimum	-25.8	-31.5	-36.8	-24.5	-8.4	0.9	1.7	3.8	-0.8	-6.8	-25.0	-27.8	-15.1
Average	-23.1	-28.0	-31.8	-19.2	-5.5	3.7	5.4	8.2	2.5	-4.7	-21.4	-23.4	-11.4
1978													
Avg. maximum	-17.1	-23.0	-20.4	-10.7	-4.2	5.8	12.7	9.8	5.6	-10.9	-10.6	-20.3	-7.0
Avg. minimum	-23.2	-29.0	-29.8	-22.2	-11.1	-0.2	4.0	0.6	-0.3	-14.9	-18.9	-26.3	-14.3
Average	-20.1	-26.0	-25.1	-16.5	-7.6	2.8	8.4	5.2	2.6	-12.9	-14.8	-23.3	-10.6
9-yr mean (1970-78)													
Mean maximum	-24.8	-27.7	-25.2	-14.3	-3.3	5.6	10.4	9.3	2.8	-8.9	-16.7	-24.1	-9.7
Mean minimum	-30.8	-34.0	-33.0	-23.9	-9.0	0.3	3.4	2.5	-1.8	-13.9	-22.7	-29.9	-16.1
Mean Average	27.9	30.9	-29.0	-19.1	-6.2	2.9	6.9	5.9	0.6	-11.4	-19.8	-27.0	-12.9

Source: Walker et al., 1980

TABLE B-2

MEAN MONTHLY COASTAL CLIMATIC DATA APPLICABLE TO PRUDHOE BAY

	J	F	M	A	M	J	J	A	S	O	N	D	M
Temp (°C)	-29.2	-31.8	-31.0	-20.2	-6.7	2.6	6.4	4.87	-0.8	-12.5	-19.0	-25.3	-13.6
Precipitation (cm) Total	10.2	8.9	5.1	4.3	6.4	13.0	22.4	26.7	23.9	21.3	10.2	7.4	13.3
Snowfall (cm)	15.0	8.1	7.4	6.6	7.9	3.8	1.0	4.1	16.3	24.4	14.5	9.7	9.9
Snowcover (cm)	40.6	43.2	40.6	38.1	12.7	—	--	—	—	20.3	30.1	33.0	32.3
Wind (m/sec)	6.3	6.2	6.0	5.4	5.5	5.1	4.7	5.2	5.8	6.4	6.7	6.2	5.8
Prevailing Wind Directions	W	W	W	W	E	ENE	ENE	E	E	E	E	E	ENE
Relative Humidity (%)	68	68	68	75	86	89	89	91	91	84	74	68	79

Source: Everett and Parkinson, 1977

*1970-1973 means

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ASSESSMENT OF
THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S
DAMAGE CASES FOR THE STATE OF ALASKA

OIL AND GAS PRODUCTION WASTES
NORTH SLOPE, ALASKA

May 1987

Prepared by
THE STANDARD OIL COMPANY

6868V

OIL AND GAS PRODUCTION WASTES
EPA DAMAGE CASE ASSESSMENT
NORTH SLOPE, ALASKA

Under the 1980 amendments to the Resource Conservation and Recovery Act (RCRA), Congress exempted several types of solid wastes from regulation as hazardous waste. Oil and gas exploration and production wastes, which included drilling fluids, produced water, and other associated wastes, were exempted because they were representative of a high volume, low toxicity waste. At the same time, Congress further instructed the Environmental Protection Agency (EPA) to conduct a comprehensive study on the adverse effects, if any, of these oil and gas wastes on human health and the environment. A final report was to be submitted to Congress by October 1982. Work on the Congress-required study was initiated by EPA following a suit filed by the Alaska Center for the Environment in August 1985. EPA is currently conducting the production waste study under a consent decree which contains a December 31, 1987 deadline for issuance of a final report to Congress.

As a part of the production waste study, EPA is reviewing damage cases to ascertain the potential damage to human health and the environment due to these wastes. In the October 1986 draft technical report on production wastes, EPA indicated that the damage cases included in the report would emphasize recent cases that would likely reflect current waste management practices, cases that illustrated clear relationships between environmental damage and specific waste management practices and cases where the most significant damage has occurred.

Twelve damage cases for the North Slope of Alaska were prepared by EPA and recently released for public comment. A review of the Alaskan damage cases indicates that they mainly concentrate on outdated practices, incorrectly indicate that the outdated practices are similar to current production operations in Prudhoe Bay, grossly misinterpret quantitative data, display extreme bias in numerous speculative statements, and improperly cite references in a fashion that misleads the reader.

Because the majority of the damage cases involved suspected environmental damage due to reserve pit operations, it is important to note that the Alaska Department of Environmental Conservation (ADEC) has proposed amendments to the Alaska Solid Waste Regulations that will require that Alaska Water Quality Standards be met at a distance of 50 feet from the boundary of the reserve pits that contain drilling wastes. These amendments, which are expected to be promulgated by July 1987, should further ease any concerns for potential environmental damage resulting from the use of reserve pits. Summarized below are the principal comments of the Standard Oil Company on the North Slope damage cases followed by a detailed analysis of each damage case.

National Petroleum Reserve, Alaska (NPRA) Sites: AK 11 - AK 17

Oil and gas exploration in the NPRA, located west of Prudhoe Bay on the North Slope of Alaska, spanned a period from 1944 to 1981. Final cleanup and restoration work was performed under contract to the U. S. Geological Survey (USGS) in 1984.

- The most erroneous speculations are statements made in the damage cases directly comparing actions at the old, unattended NPRA exploration sites to current construction and operating practices in Prudhoe Bay. The implication in the damage cases are that all reserve pits are left unattended and often breach or overflow during breakup. Current exploration site practice is to use pits that are excavated into the permafrost for drilling fluid disposal which are covered with 2-4 feet of soil upon completion of drilling activities. The Prudhoe Bay production facilities use, and have used for years, reserve pits built during the summer months with compacted gravel, rather than in the winter with frozen, uncompactable sand, gravel and topsoil as was the case at the NPRA sites. Prudhoe Bay pits are inspected daily to guard against overtopping of pit fluids during breakup and various fluid management techniques are employed to reduce water levels within the pits.

- The water chemistry data used in the damage cases to illustrate high levels of heavy metals and hydrocarbons around the exploration sites were grossly misinterpreted. Data in the reference cited (USGS, 1986) was given in a dry weight basis (milligrams per kilograms) and the author of the damage case interchanged it with parts per million on a wet weight basis. The values stated in the damage case are overstated by as much as 1,000 times.

- The damage cases speculate that the sites may remain barren of vegetation for over 30 years. A review of the cited USGS reference indicated to the contrary. Areas where vegetation was killed began to repopulate naturally within 3 - 5 years of the incident and the area of impact was generally less than 1.5 acres.

- Misleading statements such as "vegetation kills extend out to 300 feet from the reserve pit" impair the credibility of the damage cases. The reference cited in the USGS report reads "these kills extend 200 - 300 feet, varying in width from a few inches to as much as five feet".

Prudhoe Bay Studies: AK 06 - AK 08

- The three studies conducted by the Fish and Wildlife Service attempt to establish that releases of various constituents from reserve pits in Prudhoe Bay have caused invertebrate diversity to decline in adjacent ponds. Furthermore, the studies speculate that the decline in invertebrates could cause an impact on waterfowl populations in the area. The studies were flawed on several technical points. For example, nutrient levels were not measured, thus the ability of the ponds to sustain invertebrate populations is not substantiated. In another example, FWS statistics highlighted that reserve pit water was different chemically and biologically from the control ponds. The proper comparison should have been limited to ponds adjacent to the reserve pits versus the control ponds. Lastly, in studying the responses of experimental Daphnia populations in pits and ponds, FWS acknowledged that there were alternative explanations for the findings, including natural temperature and nutrient differences.

- The FWS reference cited for Case Number AK 06 indicates an October 1986 date for the report. The October 1986 report has not been released by FWS for public access and therefore it is inappropriate to use it as a damage case reference. An August 1985 draft of the referenced report was made available for review and received significant criticism for its lack of technical soundness.

Storkensen Point Site: AK 09

- The study referenced in this damage case (USFWS, 1977) was one conducted to assess waterfowl populations in the wetlands around Storkensen Point, Alaska. Within the study area, an oil spill was discovered near an old exploration site that damaged vegetation and water quality in a small tundra pond. No quantitative data regarding the spillsite is given, yet the USFWS author speculates on potential oil spill damage to waterfowl and wetlands caused by oil and gas production in general. Oil spills in Prudhoe Bay are cleaned up immediately upon discovery. Most spills are confined to the gravel work pads with very few even impacting tundra vegetation or water quality.

North Slope Salvage, Inc. (NSSI) Site: AK 10

- The NSSI site, in Deadhorse, Alaska, represents a past practice that was properly identified and expeditiously cleaned up to the satisfaction of EPA and the Alaska Department of Environmental Conservation (ADEC).

An Evaluation of the Environmental Protection Agency's Damage Cases for the State of Alaska
File Reference Number AK 06

In 1983, Fish and Wildlife Service, Fairbanks Office, initiated a field study to measure water quality parameters and macroinvertebrate abundance in reserve pits, ponds "adjacent" to reserve pits, ponds distant from reserve pits (35 m to 115 m) and control ponds (far removed from developed areas).

Basically, the FWS report was a comparison of water quality measurements and macroinvertebrate communities between ponds and reserve pits. This is not a true "study of the effects of reserve pit discharges on water quality and the macroinvertebrate community of tundra ponds". Reserve pit discharges were not analyzed at the point of discharge. Rather, this is a comparison of water quality among reserve pits and natural ponds--more of a waste characterization than a damage case.

There were several technical difficulties with the study design and methodology as well as implementation questions. The project was flawed seriously in several technical respects. In response to industry concern with the August 1985 version of the report, FWS conducted a briefing session and slide show in September 1985. Attendees included ARCO, Standard, USGS, ADEC, FWS, and DNR. This presentation was to review the 1983 studies and describe the work they had conducted in 1985 that would be added ultimately to the report. This briefing generated more concerns than it ameliorated. As more details were discussed about the project, the oil industry became more concerned with the technical credibility of the results since they would be important in the regulatory arena.

This study did not collect data in such a manner that would allow for conclusive determination of impacts from reserve pit discharges. Rather, it is more a comparison of water quality differences between pits and ponds. There were factors not measured or differentiated within this study that may have been operable influencing some of the differences that were observed. For example, nutrient levels were not measured in the ponds--thus the ability of the ponds to sustain invertebrate populations is not substantiated. This further weakens any conclusions regarding assumed impacts from reserve pit fluids since the ability of the pond to sustain invertebrates has never been established. There was no attempt to confirm or isolate that reserve pit fluids were solely responsible for the water quality differences observed.

No evidence was presented in the source reference to substantiate the statement in the damage case report that "The impact of oil activity on the North Slope is significant as this is an important nesting, rearing, molting and feeding ground for approximately 150 species of sea and shore birds, waterfowl, raptors and passerines" (emphasis added). Unless there is evidence to support that there has been a significant impact to 150 species of birds as this statement implies, the statement should be deleted.

An Evaluation of the Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK 07

A field method was developed in the summer of 1985 to evaluate the toxicity of reserve pit fluids and discharges into tundra ponds and nearby areas. The bioassay technique involved placing *Daphnia* in waxed cold cups with monofilament mesh over the ends to prevent escape and allow water flow during the experiment. Cups were placed in reserve pits and in near, distant, and control ponds for 24 to 96 hours. At the end of each 24 hour interval, cups were retrieved at random and counts were made of live, floating, and dead *Daphnia*. Water quality measurements were collected at each test site prior to performing the field bioassays.

Survivorship of *Daphnia* was lowest for those animals placed in reserve pits for 72 to 96 hours. *Daphnia* in controls and experimentals (near and distant ponds) exhibited greater survivorship after prolonged exposure.

The exact purpose and usefulness of this bioassay technique as applied to damage case assessment is not readily apparent. The experimental procedure itself has the potential to cause significant mortality to *Daphnia* regardless of the water quality parameters being examined. This study found that reserve pits differ substantially from control ponds in their ability to sustain small *Daphnia* populations under experimental conditions. The overall purpose of this study seems to be to compare reserve pits and other ponds rather than to assess impacts due to the presence of waste materials. The study provides very little useful information in relation to impacts of oil and gas development activities on aquatic ecosystems in the arctic.

This study provides no information on which to base damage case assessment; it was intended to describe a technique that may be useful in this regard. There are several serious flaws in the methodology that suggest the results may be questioned. Inter-pond variability was high enough among the controls and experimentals to make assessment of differences extremely difficult. Another serious limitation of this study is that many observations on differences in behavior of *Daphnia* after exposure to experimental conditions are qualitative; no data were collected to document apparently aberrant behavior.

The purpose of testing the technique within reserve pits is not readily apparent. In many cases, reserve pit fluids are discharged during breakup when sheet flow across the tundra is high. Organisms will not be exposed to undiluted reserve pit fluids.

The primary conclusion from this report is that tundra ponds and reserve pits differ in their ability to support small experimental *Daphnia* populations for short periods of time. The report did not attempt to characterize the contents of reserve pits or to quantify movements of reserve pit fluids (due either to discharge or to seepage) from the source to wetland tundra. There was no assessment made of the impacts of reserve pit fluids on aquatic environments.

An Evaluation of the Environmental Protection Agency's Damage Cases for the State of Alaska
File Reference Number AK 08

A limited survey of 5 drill pad experimental areas and 3 control ponds was conducted in June 1985 to study the effects of reserve pit discharges on selected tundra ponds. Increases in conductivity, total dissolved solids, and total organic carbon were recorded at 7 of 9 distant and near ponds associated with the drill pads experimental area compared to the control ponds; and corresponded to high concentrations of these materials at respective reserve pits. B, Cr, Fe, and Mn were present in two reserve pits at levels higher than those considered safe for aquatic life.

Laboratory experiments with arctic grayling and Daphnia showed no acute toxicity when these animals were tested at 100% strength reserve pit fluid. Fecundity and growth were reduced in some daphnids exposed for 42 hours to reserve pit fluids diluted to 25% or less of full strength. Test dilutions from three reserve pits showed increases in production and growth for Daphnia, which may be related to an increase in food availability in some reserve pit fluids. Several toxic trace metals (Cr, Pb, and Zn) were not accumulated in tissues of fish during laboratory experiments.

This report is incomplete because many of the important analyses had not been conducted when the report was issued. One of the primary weaknesses is the failure to establish a link between elevated levels of some organic or inorganic components in ponds and lowered productivity of those ponds in terms of food organisms for waterbirds. Failure to establish that linkage reduces the usefulness of this report in assessing damage to tundra ponds and to waterbirds associated with those ponds due to occasional reserve pit discharges.

Reserve pit fluids are not routinely discharged onto the tundra. These pits are pumped only when necessary to minimize seepage and/or prevent breaching of the pit wall or other damage to the well pad or associated structures. Additionally, current regulations require that a reserve pit may not discharge for a period of at least one year following its last use. The frequency and volume of discharges, therefore, depends on the amount of input during the years preceding the last discharge. In some cases, reserve pits may need to be pumped only once every three to four years.

The four reserve pit discharges documented in the report occurred during June when natural runoff on the tundra is at its peak. This yearly "flushing" of wetland tundra would prevent many toxic or potentially toxic substances from accumulating in tundra ponds.

The report title states that the effects of these fluids on fish and waterfowl habitat were being examined. There is no evidence presented that shows any use of the near, distant, or control ponds by fish or waterfowl. Many ponds on the North Slope are not used by waterfowl because of size, low natural productivity, presence of predators, or other factors. Depth probably limits use of most ponds by fish. In summary, this report does not describe the effects of drilling fluids and their discharge on fish and waterfowl habitat in Alaska.

Evaluation of Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK09

In 1977, the U.S. Fish and Wildlife Service (USFWS) published a report entitled Water Birds and Their Wetland Resources in Relation to Oil Development At Storkersen Point, Alaska (Bergman et al., 1977). This study is on the bird populations and their relationship to the wetlands in the Storkersen Point area. In the report, there is a paragraph about a pond that was damaged by an oil spill at Storkersen Point. Although no sampling information on the pond is presented, the report states that severe oil pollution was indicated by the destruction of all invertebrate and plant life in the contaminated pond and it would be useless as a food source for water birds. The authors then speculate that this pond will not likely be repopulated and that contamination could spread to adjacent areas. There is no recent information provided concerning the current state of the pond to support this speculation. The speculation that the pond would not likely be repopulated can be refuted by experimental studies done on ponds receiving oil spills in the Arctic (Barsdate et al., 1980).

The problem with relying on the referenced report for the damage case is that it provides limited information on the site. The incorrect underlying assumption in the USFWS report is that there must be severe impact on the tundra from any oil spill. This assumption of severe impact in the damage case, followed by the statement that there are hundreds of spills that occur each year at Prudhoe Bay, suggests that there must be severe impact to the area from these spills. This is not the case, as most of the oil spills in the Prudhoe Bay area never even reach the tundra or its waters. Most of the spills are on gravel pads and roads in the Prudhoe Bay area. Of the spills that actually reached the tundra, most occurred during the winter when the tundra was frozen, and even then only small areas were affected. Regarding the damage case statement that there are 600 spills reported every year in the Prudhoe Bay production area, it is unclear where this number comes from as it is not cited in the reference.

Additionally, numerous federal and state regulations regarding pollution control exist, and most of these regulations have been implemented since the writing of the Fish and Wildlife Service report. Mitigation for spills involves the incorporation of spill prevention and contingency planning aspects into the design and operation of all oil and gas facilities. Immediate spill cleanup and use of effective restoration practices are essential for environmental protection and are routinely practiced by the oil industry.

Evaluation of Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK10

The damage case cites an isolated occurrence in 1983 of improper storage of used drums by a contractor, North Slope Salvage Inc. (NSSI), who at that time was operating a salvage business on a gravel pad within Tract 57 at Deadhorse, Alaska. This business is no longer in operation. The following summary was extracted from the report submitted to the Alaska Department of Environmental Conservation (ADEC) and Alaska Department of Natural Resources (DNR) by ARCO Alaska, Inc. (ARCO) on behalf of the Prudhoe Bay Unit operators on December 1, 1983 (ARCO, 1983). In June, 1983, ADEC personnel discovered oil and possible chemical seepages coming off the pad occupied by NSSI. NSSI had been engaged as a contractor for the Prudhoe Bay Unit by ARCO and Sohio Alaska Petroleum Company (SOHIO, now Standard Alaska Production Company), as well as other North Slope parties. NSSI was engaged in collecting drums which had contained oil field chemicals, draining the drums of residual chemicals for disposal, and salvaging crushed drums. When NSSI was unable to complete the cleanup of this chemical spill, the cleanup was conducted by ARCO/SOHIO at the request of ADEC. On June 29, 1983, ARCO/SOHIO assumed the lead role in the cleanup activities through a contract with Chem-Security Systems (CSSI) as the on-site cleanup contractor.

The EPA case attempts to create the impression that drums and spilled wastes were left as is, causing a lasting and permanent effect on the North Slope environment. Although the damage case recognizes that special precautions had to be taken for the cleanup, it later emphasizes that the discharges were discovered in June and the cleanup did not begin until July 2 after breakup when substances were carried into the tundra. The oversight in the damage case is that containment measures were undertaken to protect the environment while contractor arrangements were made for cleanup and while site-specific safety and operations plans were developed and approved by ADEC and DNR. ARCO/SOHIO developed this plan, with Chem-Security, the contractor hired by the oil companies. The cleanup was then executed according to the approved plan. ADEC and DNR inspected and approved the pad cleanup on August 5, 1983. After the cleanup a monitoring program was undertaken of the adjacent tundra areas and water samples were taken from nearby ponds. These tests showed that the water and tundra was clean.

The case presented by EPA actually conflicts with their cited document, the ADEC report entitled "Report on the Occurrence, Discovery, and Cleanup of an Oil and Hazardous Substances Discharge at Lease Tract 57 Prudhoe Bay Alaska". The EPA damage case indicated that no regulations were violated. However, the ADEC report documents that they had contacted NSSI in June, 1983 to notify them that an oil and hazardous substance spill report needed to be filed with the state. Later that month NSSI was issued two "Notice of Violations" from the ADEC: one on June 14 and another one June 24, 1983, according to this report. The EPA compliance section information suggests that inadequate policing of North Slope operations resulted in this incident. The ADEC report notes a number of visits to the NSSI site starting in November of 1982 prior to the incident. The damage case states that after this incident there was more funding allowed for enforcement activities, although there is no reference for this information. There is no documentation for the source of the policing information, and this information is not in the ADEC document.

An Evaluation of the Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK11

The final wellsite report on the National Petroleum Reserve - Alaska (NPRA) provides background information, summarizes exploration and restoration activities and provides an assessment of selected sites. Twenty-eight explorations wells were drilled during the second exploration phase in the NPRA from 1974-1981. At most of these sites, excavated reserve pits with above-ground berms were placed adjacent to a drilling pad. Several sites lacked reserve pits and discharged mud directly to the tundra. Although pad material was pushed into the reserve pit during some of the restoration operations, the majority of the reserve pits were left open. Because the pits were unattended, many breaches and leaks occurred from melted snow in the pit, and in some cases, thawing ice wedges and construction material caused the berm to slump and leak. Different construction and management techniques are used at Prudhoe Bay.

Currently, reserve pits are closed upon completion of drilling activities. Pits at exploration drilling sites are now built below ground, are generally used for less than a year, and are closed shortly after drilling is complete. Other methods are used at production reserve pits to handle waste until the site is closed. Fluid management, which is being used at sites at Prudhoe Bay, can prevent breaching. At Prudhoe Bay, fewer than five incidents of dike overtopping/breaching have occurred during the past five years for the approximately 130 reserve pits in use there. In those cases where breaching occurred, immediate cleanup was undertaken.

Additionally, proposed State solid waste management regulations require that water quality standards be met at the facility boundary through the use of fluid management, liners, or pit closure. Along with these new regulations, other construction practices have already been implemented, including use of thawed materials for construction to allow for better compaction, construction during summer, and using materials that decrease the permeability of the reserve pit walls.

The EPA case is misleading in stating that it is difficult to reclaim and revegetate sites due to the severe climate and fragile nature of the vegetation and that sites near the coast would be almost permanently barren. The NPRA report concludes that "...there is a plasticity in the Alaska tundra flora and fauna which provides a capacity for adapting to several commonly occurring disturbances associated with hydrocarbon exploration." At the sites the damage to the vegetation was relatively small and localized, usually limited to less than 1.5 acres per site. In most cases, some vegetation was recolonizing the areas, as occurred at previous exploratory wells in this area, where the vegetation effects have been relatively short-term. The USGS author summarizes: "Drilling muds eventually become overgrown by plants; salinity diminishes; and impoundments and thermokarst depressions are colonized by water-tolerant vegetations species if the water depths are not too deep."

An Evaluation of the Environmental Protection Agency's Damage Cases for the State of Alaska

File Reference Number AK12

The Awuna Test Well was drilled from a gravel pad in the National Petroleum Reserve - Alaska during the winters of 1979-80 and 1980-81. A reserve pit was excavated so that all drilling wastes would be contained below tundra level after completion of drilling operations. The site was left intact and unattended when drilling operations were completed in April of 1981. Fluids accumulated in the reserve pit due to the accumulation of snow over the winter and runoff from the drill pad. As a result, fluid levels in the pit were elevated and the reserve pit wall failed. Diluted pit fluids flowed onto the tundra and affected some vegetation.

The EPA damage case assessment for this exploratory well was misleading on several points. EPA maintains that reserve pit fluids completely killed vegetation in the half-acre area affected by the spill. Next, EPA speculates that the drill pad soils were contaminated with salt and hydrocarbons and that the areas of pad contamination would remain barren for many years. The damage case also states that hydrocarbon residues were spread over the tundra area during flaring. Again, this is based on conjecture.

The USGS report indicates that diluted fluids reached the tundra and that these fluids "mildly" affected many tundra plants (USGS, 1986). There are no data to support EPA's contention that all vegetation was killed in the area affected by the fluids and that the area will remain barren. More importantly, it should be stressed that practices at exploration sites now dictate that excavated pits be backfilled upon completion of drilling activities. This practice results in freezeback and immobilization of the waste material. Therefore, pit berm breaching is not an issue at abandoned well sites.

Those plants affected by the spill were growing vigorously by the time the well site assessment was completed in 1984. Warming and moisture from the pit fluids, which likely contained nutrients and fertilizers from the drill pad revegetation program, actually enhanced plant growth in the site of the breach. In addition, because some vegetation was killed, the plant community on the affected tundra was thinned, thus reducing competition from the neighboring plants and promoting plant growth.

The purpose of the planned discharge of reserve pit fluids onto the tundra after breakup in 1981 was to relieve the pit of some fluid. This was a regulated discharge, done after examination of the pit fluids and determination that they were environmentally safe. There is no evidence that dewatering of the pit onto the tundra caused the vegetation damage EPA implies.

Because no chemical analyses were ever completed on the drill pad soils, there is no evidence linking salt and hydrocarbon contamination with barren areas on the drill pad, as EPA speculated. The USGS report speculates that the presence of very hard, dry soil, and not the chemical contents in the soil, resulted in the lack of plant growth on the pad. In addition, it should be noted that the overall vegetation on the pads indicated relatively favorable conditions for plant re-establishment.

An Evaluation of the Environmental Protection Agency's Damage Cases for the State of Alaska

File Reference Number AK13

The East Teshekpuk Test Well was drilled in the National Petroleum Reserve - Alaska (NPRA) during 1976. This drill site is on a peninsula in Teshekpuk Lake. The reserve pit was excavated below ground level during the winter, and the excavated material was combined with sand to construct the drill pad and pit berms. After completion of drilling, reserve pit fluids leaked through the pit berm, and some fluid reached the ice of Teshekpuk Lake and the polygon basins near the reserve pit. Most of the spilled fluids were recovered and returned to the pit, which was then closed with material from the drill pad. This is the oldest site examined in the 1984 USGS assessment study (USGS, 1986).

The damage case assessment incorrectly identifies damage impacts to Teshekpuk Lake sediments from discharge of reserve pit fluids onto the tundra and onto the lake. The damage case implies that reserve pit fluids have affected waterfowl which use the lake. In the waste stream analyses, EPA has identified high levels for contaminants in samples collected from the lake bed. However, EPA fails to identify that these levels were only for the dry soil phase, which was less than one percent of the total sample. As a result, the actual contamination is overstated. This contradicts the USGS conclusion, after reviewing the lake samples, that the site had no significant environmental impact from the reserve pit fluids. In fact, after considering the methodology of the chemical analyses, the USGS report states that "it is evident that there were not highly elevated levels of chromium, chlorides, oil and grease contained within the Teshekpuk Lake sediments."

A further examination of tundra at this site indicates that damage from pit fluids was confined to several polygon basins near the buried reserve pit in an estimated area of no greater than 4,000 square feet. In areas of vegetation damage, sensitive plant species were killed, yet there was clear evidence of recolonization.

The compliance issues section of the damage case concludes that this site is similar to pads and pits at Prudhoe Bay. This is not the case. Current practice for exploration sites includes below-ground pits closed out in a freezeback state upon completion of the drilling. Pits at Prudhoe Bay production sites are not excavated, are constructed principally of gravel rather than sand, and are not built in the winter. In addition, new management and construction techniques have been implemented for production sites, including fluid management, use of less permeable construction material, and liners. These measures will guard against seepage and breaching.

An Evaluation of the Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK14

The Ikpikpuk Test Well was drilled from a gravel pad in the National Petroleum Reserve - Alaska (NPRA) during two succeeding winters beginning with 1978-1979. This is an old, unattended exploration site built with a below-ground reserve pit surrounded by a berm. The berm was breached, allowing the escape of reserve pit fluids, which caused the loss of some vegetation within a 1,000-square-foot area. The USGS report referenced in the damage case is factual and informative (USGS, 1986).

The primary weaknesses of the EPA damage case are gross generalizations about impacts without direct substantiating evidence. While the EPA case identifies impacts to vegetation and implies impacts to waterfowl and caribou, it is clear that the only damage actually identified at this site was to several species of vegetation. The EPA case refers to an unsuccessful revegetation effect, when in fact, revegetation was only attempted on the regraded gravel drill pad. Furthermore, the damage description implies that because waterfowl and caribou are present in the area, some impacts to their populations will result from the incident.

EPA indicates that the fluids escaping the reserve pit killed wet sedge and mesic tussock meadow plant communities. It also states that hydrocarbons from a broken flare line were released during pit breaching, although this was not determined definitely in the USGS report. Regardless of the cause of damage, 17 of the 24 species of plants in the sedge and meadow communities were not affected in the area of impact, which was estimated to be less than 1,000 square feet. Further, the USGS author states that the damage appeared to have reached its maximum and there was evidence of recovery in 1984. Those areas of light damage actually appeared to have been stimulated to increased growth. This contradicts EPA's damage description, which speculates that the vegetation "kill area" may remain barren for over 30 years.

Perhaps the most erroneous speculations are statements directly comparing this incident at an unattended exploration site to current construction and operating practices in the production area of Prudhoe Bay. The implications are that the reserve pits in Prudhoe Bay are left unattended and often breach during breakup, thus releasing toxic substances onto the tundra. There have been fewer than five reserve pit dike washouts over the past five years in Prudhoe Bay. Breaching is hardly a frequent occurrence and the pits are inspected daily. Current practice at exploration sites is to remove spilled hydrocarbons immediately and close out the reserve pit upon completion of drilling activities. Proposed State solid waste regulations will further lessen impacts from production operations by requiring water quality standards to be met at the facility boundary through the use of a combination of reserve pit fluid management, liners or pit closeouts.

An Evaluation of the Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK15

The Inigok Test Well was drilled from the spring of 1978 to the spring of 1979 from a gravel pad in the National Petroleum Reserve - Alaska (NPRA). This exploration site, which was abandoned, utilized an excavated reserve pit surrounded by an above-ground berm. In 1979, the pit filled during heavy spring runoff causing seepage through the one of the pit berms. After the leaching was discovered, the pit was covered. The leachate from the pit killed vegetation as it moved toward an inlet connected to Lake Inigok. The total extent of the damage to the vegetation from leachate appears to be about 1.5 acres. An impact study on the inlet and Lake Inigok showed the leachate to be confined to the inlet. The USGS report referenced in the damage case provides the basis for the damage case (USGS, 1986).

The EPA damage case should describe the site clearly, summarize the damage, and state compliance issues relevant to that site. In so doing, the case should include only factual information and not make unsubstantiated inferences. The damage case suggests the site is undesirable to organisms and that the pit fluids have polluted a nearby lake -- with the incorrect implication that this occurs at Prudhoe Bay. In addition, although mitgratory waterfowl, shorebirds, and caribou may be in the vicinity of this site, there is no link to substantiate spill problems at this site with wildlife using the area. The implications are erroneous and cannot be supported by the USGS report or current operational practices. The Inigok Lake Aquatic Impact Study was designed to determine any effects from the leachate. The study showed that the leachate was confined generally to the inlet, particularly the bottom layers. The food the fish in the lake were feeding on was not from the inlet area. The USGS report does not document the pollution of Lake Inigok that is hypothesized by EPA.

The current practices for both construction and operation of reserve pits conflict with those in the compliance issues summary of the damage case. A reserve pit at an exploration drilling site is usually below ground, is used for less than a year, and is closed out shortly after drilling. At production sites, above-ground walls are used, and the waste in th pit is managed until the site is closed. Fluid management is one of these methods in use at Prudhoe Bay. Additionally, the proposed State solid waste management regulations require water quality be met at the facility boundary through the use of fluid management, liner or pit closure.

An Evaluation of the Environmental Protection Agency's Damage Cases for the State of Alaska File Reference Number AK16

The Seabee Test Well was drilled during the summer of 1979 from a pad in the National Petroleum Reserve - Alaska (NPRA). Operations at this abandoned exploration site utilized an excavated reserve pit surrounded by an above-ground berm with a well pad on one side. The well was suspended in the fall of 1979 for a short period, and JP-5 (an arctic-grade diesel) was used in the top part of the well. The JP-5 was later flared during reentry in October 1979. Fluids leaked from the site and partially killed vegetation in a swath a few inches to five feet wide for a distance of 200 to 300 feet from the site. However, the fact that plants are reinvading the barren areas suggests that the original damages, which were relatively minor, are further abating. The site ranks low for waterfowl habitat compared to sites nearer the coast, but moose and caribou occasionally visit the area.

The EPA damage case is sparse on information from the USGS report but uses speculation to determine damaging factors and relate this information to current practice. The case discusses the vegetation kill in the drainage below the reserve pit and considers the possibility that toxic substances from leaking fluids and from spraying of JP-5 caused the vegetation kill. However, the USGS author states that the chemical data provide no evidence of toxic substances that might explain vegetation kill, although the substance clinging to the plants appeared to be some type of hydrocarbon. There is no information to support that the JP-5, flared in October, sprayed on the surrounding area. The flaring occurred in October when snow has already covered the frozen ground on the North Slope. The compliance issues section erroneously concludes that these are similar to practices presently employed.

At Prudhoe Bay, below-ground reserve pits are generally used at exploration drilling sites for less than a year, and these pits are closed shortly after drilling is completed. On the other hand, above-ground pits are used at production sites. Prudhoe Bay reserve pits are built in summer with thawed gravel, which can then be compacted. In some of the newest pits, better compaction and a mix of material are used to decrease the permeability of the pit walls. In addition, waste handling practices such as fluid management are used until the site is closed. The fluid must either meet State water quality standard for discharge or be injected in a well. Proposed State solid waste management regulations require that water quality standards be met at the facility boundary through the use of fluid management, liner, or pit closure. Pit wall breaches have occurred in only five pits out of 130 in the last five years. In addition, there would be no flaring at production sites since test separators have been installed and are utilized instead of site flares. The reserve pits at Prudhoe Bay are also inspected daily to insure against breaching.

An Evaluation of the Environmental Protection Agency's
Damage Cases for the State of Alaska
File Reference Number AK17

The Tunalik Test Well was drilled over a 16-month period beginning in the fall of 1978 in the National Petroleum Reserve - Alaska (NPRA). This well was drilled from an all-season gravel pad insulated with Styrofoam to prevent thermokarsting. The site is frequented by migratory waterfowl, shorebirds and caribou. The runoff water from the tundra that surrounds the site has eroded channels into the reserve pit, and the east side of the pit has breached. This has resulted in damage to the vegetation in the drainage downslope from the reserve pit. Additionally, oil and grease residue was present in the soil and vegetation for at least 1/4 mile from the site. The pad area is generally a dry habitat so that portions of it could remain barren for a long period. However, plant colonization on the pad was occurring from naturally seeded species and the diversity of grasses was greater than found on any other drilling sites in the study area.

The EPA damage case erroneously implies that site construction and operating practices are the same at Prudhoe Bay as at the NPRA exploration site. Current practices for reserve pits at Prudhoe include closure upon completion of drilling activities. An exploration drilling site is generally utilized for less than a year and is closed out shortly after drilling is completed. For production reserve pits, the waste is managed through practices such as fluid management until the site is closed. Further, the proposed State solid waste management regulations require that water quality standards be met at the facility boundary through the use of fluid management, a liner, or pit closure.

Additionally, with new practices at production sites flaring would not be used. The EPA speculates, without any substantiation from the USGS report, that flaring of JP-5 during reentry of the well results in spraying of hydrocarbons around the well site, often killing vegetation. Instead of flaring, test separators installed at the pads are utilized instead of site flare pits. If a well is to be re-entered at a production site, fluids from the winterizing are injected downhole and not flared.

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THE PRUDHOE BAY RECORD

July, 1987

A White Paper Prepared By
THE STANDARD OIL COMPANY

THE PRUDHOE BAY RECORD

1. INTRODUCTION

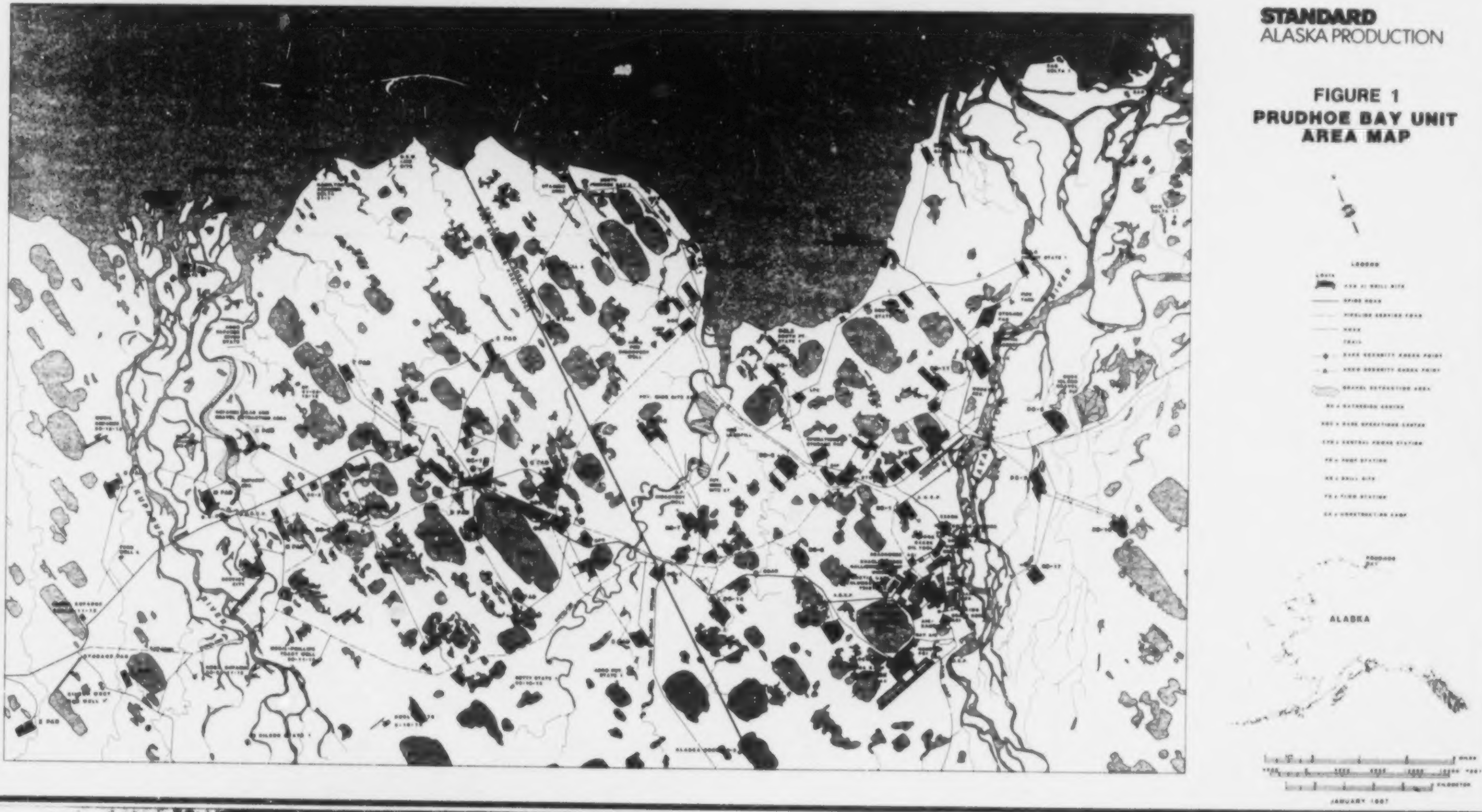
During Congressional review and discussion regarding potential oil exploration and development on the Coastal Plain of the Arctic National Wildlife Refuge (ANWR) it is logical to review the environmental record of the Prudhoe Bay Oilfield (Figure 1) located about 75 miles west of ANWR (Figure 2). Environmental protection at Prudhoe is the major responsibility of the two operating companies, but ultimately reflects the commitment of the entire industry to conduct exploration and development activities in an environmentally responsible manner.

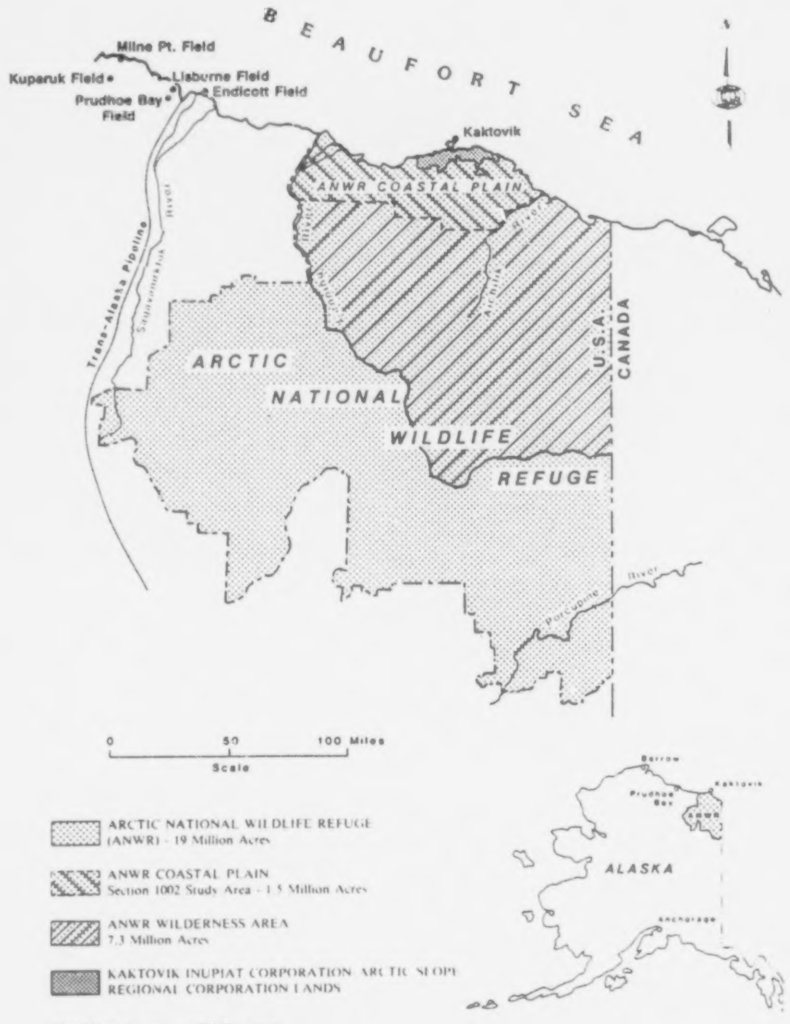
Oil was discovered at Prudhoe Bay nearly 20 years ago; the oilfield itself has been in production for 10 years. Within these timeframes and continuing with the development of the Kuparuk, Lisburne and Endicott oilfields, there has been a significant increase in knowledge specific to the arctic regarding operating technology, the environment and the potential environmental impacts from oilfield activities. In actuality, the environmental "record" is not a static entity. The record could be described more accurately as reflective of a successful process involving the evolution and interaction of environmental knowledge, operating technologies and regulatory approaches. In the 10 years that the Prudhoe oilfield has been in production, the integrity of the arctic ecosystem has been maintained--there is no evidence of signficant adverse impact to the air and water quality, or to the plants and animals of the oilfield. This is the starting point, or baseline of a record that, over time, is being continually refined and improved.

Standard Alaska Production Company (SAPC) operates the western portion of the Prudhoe Bay Oilfield on Alaska's arctic coast; ARCO Alaska, Inc. operates the eastern portion (Figure 1). These operators produce the North Slope oil for the consortium of companies that own the Prudhoe Ba

STANDARD
ALASKA PRODUCTION

FIGURE 1
PRUDHOE BAY UNIT
AREA MAP





Modified from: ASRC 1986

FIGURE 2 ARCTIC NATIONAL WILDLIFE REFUGE

Unit. This arrangement facilitates the efficient development and production of an oilfield and designates an operator company responsible for the environmental permitting and compliance activities for the owners in addition to production operations.

This paper examines the Prudhoe Bay record regarding improvements and advances in waste management practices, increases in waste management regulation and increases in information regarding potential environmental impacts of these activities specific to the experience of Standard Alaska Production Company (SAPC). It is important to qualify that this document does not describe differences in policy, practice or interpretation of regulatory requirements that may exist among other companies involved in exploration and production activities on the North Slope. There are times when more than one approach exists to achieve a given performance standard or comply with a given regulatory requirement and different companies may implement entirely different policies or practices for compliance. The overall result however is the same: regulatory compliance and environmental protection are achieved.

2. PRUDHOE BAY ENVIRONMENTAL SETTING

2.1 The Prudhoe Bay Oilfield

The Prudhoe Bay area (Figure 2) is located 250 miles north of the Arctic Circle on Alaska's North Slope. The slope region covers approximately 76,000 square miles and extends from the foothills of the Brooks Range to the Beaufort Sea coast. The oilfield area which includes Prudhoe Bay is located in a zone about 60 miles between the Colville and Sagavanirktok rivers and about 10 miles wide along the coast. Within the boundary of the Prudhoe Bay oilfield, the actual facilities cover only about 2 percent of the available surface area; within the vast expanse of the North Slope environment, oilfield facilities cover an insignificant portion (less than 0.0001 percent) of available habitat.

The Prudhoe oilfield was discovered in 1968, but did not go into production until 1977. Since startup, over 5 billion barrels of crude oil have been produced for domestic consumption. The daily production rate of 1.5 million barrels represents about 20 percent of U.S. production. There are 6 production centers that process oil, gas and water from 35 drilling sites. There are over 800 wells that have been drilled for the Prudhoe Unit since startup 10 years ago. Most of the wells have been for oil production, but recently more wells are being drilled for enhanced oil recovery purposes.

This large, developed oilfield is the summer home of thousands of birds and caribou. In the past 10 years, there has been no discernible decline in overall use of the area by wildlife. Prudhoe Bay continues to be an important nesting area for thousands of waterfowl and shorebirds. Central Arctic herd caribou continue to move through the oilfield during calving and insect relief periods. The Prudhoe Bay oilfield has been in existence for enough years now to represent longterm effects from oil development, and the evidence supports that wildlife and development goals are mutually achievable.

2.2 The North Slope Coastal Plain Habitat

The North Slope is underlain by a continuous layer of permanently frozen ground called permafrost. This layer is about 2000 feet deep and in the summer only the active layer--the top 18 to 36 inches of ground--thaws. The area is frozen for over 9 months of the year. During the short arctic summer and especially early in the season, most of the coastal tundra is wet. The lack of slope and presence of permafrost result in inefficient drainage making the area wet, although there is less than 7 inches of annual precipitation. Most of the drainage is by sheet flow during the high water period early in the snowmelt season when much of the tundra is still frozen.

The tundra community consists of about 250 species of tundra plants, which are characterized by low growth forms and shallow root zones. This is mainly because of the colder temperatures and substantial winds above the surface and the cold temperatures and permafrost at the base of the active layer thaw zone.

The lack of slope means that differences in relief measured in terms of centimeters produce differences in the vegetation. For example, the rims of tundra polygons, although maybe only 10 centimeters higher than the polygon centers, are substantially better-drained and support a different vegetation community than the lower and wetter centers. This produces a fine-grained mosaic of habitats consisting of sedges, grasses, mosses, lichens, herbs, and shrubs. Walker (1981) identified and mapped 44 distinct plant communities in a 97 square mile area including the Prudhoe Bay oilfield (ERT 1984).

At Prudhoe Bay, wet tundra types are predominant; dry and moist tundra types are less common and serve an important role in providing nesting habitats for a variety of bird species in early summer (Troy 1982, Herter et al. 1983). The better-drained sites often contain the most diverse flora. During the brief summer, the most notable wildlife use of the Prudhoe Bay area is by over 230 species of migratory birds and by Central Arctic herd caribou which migrate between the Brooks Range and the Beaufort Coast.

The effects of permafrost on surface hydrology have been described briefly above. Additionally, permafrost plays a major role regarding the subsurface hydrology: it effectively prevents infiltration downward and recharge to groundwater that may exist below the 2000 foot depth of the permafrost layer. No groundwater exists within the permafrost zone and the groundwater below the permafrost is saline with dissolved solids levels above 7,000 milligrams per liter (mg/l).

3. REGULATORY FRAMEWORK

3.1 Federal Perspective

The evolution of comprehensive federal environmental regulations has occurred in tandem with the oil industry's development of Prudhoe Bay. The Prudhoe Bay Oilfield was discovered in 1968; the National Environmental Policy Act (NEPA) was enacted in 1969.

Since that time, there have been substantial advances in arctic engineering technology; similarly, there have been steady increases in environmental regulatory programs and requirements. A brief review of landmark federal environmental legislation includes, but is not limited to, the Clean Air Act (CAA) of 1970; the Federal Water Pollution Control Act (FWPCA) and Coastal Zone Management Act (CZMA) of 1972; the Resource Conservation and Recovery Act (RCRA) of 1976; the Clean Water Act (CWA) [renamed FWPCA] amendments and Clean Air Act amendments of 1977--the year the Prudhoe Bay Oilfield went into production.

In 1979, the U.S. Army Corps of Engineers asserted Clean Water Act, Section 404 jurisdiction over North Slope wet tundra. The Section 404 program regulates the discharge of dredged or fill material (i.e., gravel) into waters of the U.S. and adjacent wetlands. In 1979, the Corps of Engineers determined that North Slope wet tundra met the definition of wetlands for this regulatory purpose and initiated a comprehensive Section 404 gravel permitting program. Since most of the North Slope is wet tundra and since development requires the construction of gravel pads for insulating the permafrost and providing a stable work surface, a Section 404 permit is required for essentially all oil development activities.

Since 1979 there have been additional regulatory programs developed, including, but not limited to, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. Other programs that have been in existence and may be involved depending on the specific project being reviewed include, but are not limited to, the Endangered Species Act

(ESA), the Marine Mammal Protection Act (MMPA), the International Migratory Bird Treaty Act, the Hazardous Substances Control Act, the Toxic Substances Control Act, and the Fish and Wildlife Coordination Act (FWCA).

3.2 State and Local Historical Perspective

Most of the development on the North Slope has been on State-owned lands. Numerous State environmental regulatory programs have been developed and implemented. In fact, the major area of the Prudhoe Bay oilfield was developed under the state leasing and permitting system prior to the Corps of Engineers' assertion of Section 404 program jurisdiction over wet tundra.

The Alaska Coastal Management Program (ACMP) developed under the federal Coastal Zone Management Act (CZMA) requires state and federal permits and authorizations be consistent with the policies of the ACMP. Through the consistency review process, environmental stipulations and mitigation measures are incorporated into the various and numerous permits and authorizations that are required for development activities before they can be issued; this includes the Corps' Section 404 permits.

Additionally, the State has Clean Water Act Section 401 authority for Water Quality Certification. Before activities are permitted that may effect water quality, the Alaska Department of Environmental Conservation must issue a Section 401 Water Quality Certification which may include stipulations and mitigation measures to be incorporated as part of the permit being issued. This program applies also to the Corps' Section 404 permits.

The leasing and land management regulations of the Alaska Department of Natural Resources, the environmental regulations of the Alaska Department of Environmental Conservation, and the regulatory programs implemented by the Alaska Department of Fish and Game provide comprehensive oversight for oilfield activities. The programs applicable to waste management are examined in detail in Section 4.2 of this report.

The North Slope Borough has land management regulations applicable to oilfield activities. As development has progressed on the North Slope, the number of federal, state, and local agencies involved in review and approval of projects has increased with the proliferation of environmental laws and implementing regulations. Leases and permits issued within this regulatory framework for oil and gas activities incorporate strict environmental protection stipulations and site-specific mitigation requirements.

3.3 Summary

Development-related activities on the North Slope are regulated in numerous and varied ways and are subject to a complex system of reviews and certifications involving several federal and state agencies. The major avenues for review and incorporation of environmental stipulations and mitigation measures include the Corps' Section 404 permit and the consistency requirement under the Alaska Coastal Management Program.

Table 1 provides a summary of major regulatory programs controlling oil and gas development in Alaska. The Department of the Interior has noted that oil and gas activities in Alaska are governed by more than 36 federal and five state laws, as well as 111 regulations found in six separate titles of the Code of Federal Regulations (DOI 1987).

4. MANAGEMENT OF RESERVE PITS

This section presents a brief background on reserve pit construction practices, characterization of the fluids contained in the pits, data from reserve pit discharges, impacts of pending regulations, and a qualitative assessment of potential environmental impact.

4.1 Background

Drilling sites are built on five-foot-thick gravel pads to minimize any impact on the underlying permafrost. The pads serve both to insulate the permafrost and to support heavy drilling equipment. Numerous wells are drilled from each gravel pad on the North Slope. This is accomplished by the use of a drilling technique called directional drilling. With this technique, the wells from each pad can collectively produce oil from the petroleum reservoir within approximately a two-mile radius of the surface location. Therefore, the "gravel footprint" of the drillsite, and its associated damage to the tundra is minimized.

Because numerous wells are drilled at each pad, centralized reserve pits are used to contain the waste drilling fluids and cuttings generated at the pad. The reserve pits continue to accept development drilling and workover wastes for the life of the pad. This differs from the typical practice in the lower 48 states, where a separate reserve pit is built for each well. With the use of centralized pits, less tundra is disturbed than if multiple, well-specific pits are built.

Like the rest of the well pad, reserve pits on the North Slope are generally built above-grade and are constructed of gravel. Where relatively small quantities of waste are generated (e.g., exploration wells) below-ground reserve pits are sometimes used. For both above- and below-grade reserve pits, the underlying permafrost acts as an impermeable barrier to prevent downward migration of waste constituents.

Seepage through the gravel reserve walls has been known to occur. For recently constructed pits, new designs have reduced the seepage rate considerably. To render the walls less permeable, gravel with a higher silt content has recently been used, and the gravel lifts have been shortened in order to achieve greater compaction. Furthermore, new designs for the well pad itself in effect widen the reserve pit walls by reorienting the pits so that less of the reserve pit faces the tundra.

Drilling fluids placed in the reserve pits are frozen for about nine months of the year. When the pit fluids freeze, they freeze from the top down, concentrating the suspended and dissolved solids in the bottom of the pit. In the summer as the ice melts, the cleaner upper layer of melt water often can satisfy State Water Quality Standards and can be discharged directly to the tundra under a State discharge permit. Thus, reserve pits in the Arctic serve as short-term containment devices for some waste components (e.g., melt water) and long-term disposal units for other waste fractions (e.g., rock cuttings and mud solids).

Although reserve pit designs have improved, snowmelt accumulation in reserve pits continues to be a major concern. In 1980, the first breach of a reserve pit wall occurred. As shown in Table 2, a total of six reserve pit walls have breached or overtopped in the Western Operating Area during the 17 years since the first production well pad was built at A Pad in 1970. The impacts from such occurrences have been localized and of short duration. As an example, the areas affected by reserve pit breaches at C Pad and D Pad in 1986 are showing rapid vegetation recovery in 1987 after fertilization and reseeding of the area.

In 1982, a study of reserve pits found that water in older pits not used for a year was relatively clean (Enderle and Marrs, 1983). The Alaska Department of Environmental Conservation (ADEC) began allowing controlled discharge of reserve pit water to the tundra in 1983 to prevent additional dike breaching. ADEC issued the first North Slope general permit for tundra disposal of reserve pit waters in June 1984.

The conditions of the 1984 permit established pre-discharge water quality limits for salinity, settleable solids, and visible sheen. Effluent limits were also established for metals (arsenic, barium, cadmium, chromium, lead, manganese, mercury, and silver); aromatic hydrocarbons; chemical oxygen demand; total oil and grease; and pH.

Because of numerous apparent exceedances of effluent limits in water discharged from reserve pits in the Western Operating Area in 1984 (Tables 3 through 8), ADEC modified discharge procedures in 1985 to require pre-discharge analysis of metals in reserve pit water. Further refinements in the ADEC general permit were made in 1987 which include: 1) effluent sampling of every 200,000 gallons of water discharged which equates to sampling approximately every five hours, and 2) a requirement to defer pre-discharge sampling until the contents of the reserve pits had completely melted and were completely mixed.

When examining the reserve pit discharge data, it is important to put the reported metals discharge violations in perspective. Numerous violations of the manganese standard were reported in 1984 and 1985. In 1986, the Alaska Department of Environmental Conservation eliminated the manganese limits because manganese is present naturally in the North Slope environment in high background levels.

Many violations of the arsenic limit were reported in 1984. Errors in the sampling and analytical procedures, which have been rectified, are suspected to have contributed to the majority of the arsenic exceedances in 1984. Other effluent violations, particularly salinity, have reduced significantly since the initial year of reserve pit discharge monitoring in 1984 due to improved operating practices. Further improvements are anticipated as a result of a full independent evaluation of sampling and analytical procedures that is currently planned. The analytical procedures used by the SAPC production laboratory in Prudhoe Bay are shown in Table 9. The fact remains that whether due to improvements in discharge operations, sampling techniques, or analytical procedures, the number of permit exceedances has dropped dramatically in the last two years.

Table 5 summarizes the reserve pit metals data from 1984 - 1986 and indicates that quality of the water discharged either satisfies Alaska water quality standards or generally exceeds the limit by a minor amount.

4.2 Management Practices Under the Existing and Pending Regulations

Numerous Federal, State and local permits must be obtained in order to construct and operate a reserve pit on the North Slope. This section addresses the requirements for only two of these permits: a Section 404 Clean Water Act (CWA) permit issued by the U.S. Army Corps of Engineers, and a solid waste disposal permit issued by the Alaska Department of Environmental Conservation (ADEC).

Section 404, CWA Permit. Most of the North Slope is characterized as wetlands, and thus a Section 404 CWA permit is required in order to discharge the gravel fill material needed to construct the reserve pit. As administered by the COE, a public interest review is conducted for each proposed construction project on the North Slope, including an evaluation using EPA's Section 404(b)(1) guidelines.

Permit conditions require: compliance with applicable water quality standards and CWA effluent limitations; a prohibition on discharges that harm threatened or endangered species or their habitats; and a requirement that the permittee make every reasonable effort to construct the proposed project so as to minimize any adverse impact on fish, wildlife and the natural environment.

The COE permit process also addresses, among other things, reserve pit design and the hydrology of the area. Reserve pits must be designed to be impermeable. Hydrocarbons discharged into the pits must be removed and properly disposed of as soon as practicable during the winter and within 72 hours of discovery during spring thaw.

The special conditions related to hydrology require that a minimum distance of 100 feet be maintained between the toe of the gravel pad and the ordinary high water mark of adjacent lakes and stream banks. They also stipulate that structures be installed to prevent erosion or drainage of adjacent aquatic areas. Furthermore, to minimize the destruction of tundra and other sensitive habitat, the applicant must utilize nonwetland areas and existing pads and roads to the maximum extent practicable.

Solid Waste Disposal Permit. Like the Corps of Engineers' permit process, the ADEC's existing solid waste regulations require that the reserve pit be impermeable. The underlying permafrost satisfies this criterion for downward migration. However, even with recently developed construction techniques, revised regulations (proposed by the ADEC last year) acknowledge that an absolute "no lateral migration" requirement may not be achievable in the Arctic.

Few options, if any, are available to render existing reserve pit walls absolutely impermeable. For this reason, the ADEC's revised rules which will be promulgated in August 1987, will replace the existing design standard requiring absolute containment with a performance-based standard. The revised standard will require that the State Water Quality Standards cannot be exceeded at more than 50 feet from the facility.

Arctic operators are free to use any design or operating practice to achieve compliance with the water quality standards. One option is an operating practice known as "fluid management". Fluid management entails the use of dewatering techniques to reduce the fluid level in the pit. The less fluid contained in the pit, the less seepage can occur through the pit wall.

The following dewatering techniques are currently practiced - some more than others -- to reduce the fluid content of reserve pits in the Arctic.

- Removal of clean snow from the top of the frozen reserve pit material before breakup in spring;
- Discharge to the tundra of reserve pit fluids that remain after breakup and satisfy State water quality standards;
- Road watering using pit fluids that comply with State water quality standards;
- Injection of pit fluids into the annulus of a well; and
- Disposal of fluids in dedicated injection wells.

4.3 Potential Impacts for Reserve Pits

Reserve pit wall breaching or overtopping, has been due to excess fluid levels in the pit. The "fluid management" aspect of ADEC's proposed regulations should substantially reduce the risk of a breach. Thus, seepage through the reserve pit wall to surface water is the more significant pathway of concern.

Sampling was conducted in 1986 on several reserve pit wastes in the Prudhoe Bay Unit. Liquid and solid waste samples were taken from both old

(1971) and recently constructed (1984) pits. Waste composition data are presented separately for the two fractions.

Liquid samples were taken from four reserve pits. No measurable quantities of volatile organic compounds were detected, nor did the samples exhibit any of the hazardous waste characteristics, even when using the proposed EPA toxicity characteristic leaching procedure (TCLP). See Appendix A for the quantities of contaminants detected.

Solid samples were taken from four pits and from a shale shaker on a drilling rig. Measurable quantities of the volatile compounds ethylbenzene and toluene were detected (see Appendix A). However, none of the samples exhibited any hazardous waste characteristic, including the proposed TCLP levels for ethylbenzene and toluene.

Based on the literature, the major constituent of concern regarding impacts to the environment from reserve pit water is the salt content which is reflected by measuring total dissolved solids (TDS). This is the one constituent most likely to be encountered at concentrations known to be damaging or potentially-damaging to tundra vegetation species. Numerous investigators have documented that the major constituent of concern to the environment in drilling fluids is the total dissolved solids (TDS) content, not chromium (or other heavy metals) or organics (diesel fuel) (Myers and Barker 1984, Younkin and Strosher 1980, Smith and James 1980).

Myers and Barker (1984) investigated areas of arctic tundra subjected to controlled discharges of reserve pit fluids in 1982 and 1983. They found that the single most important parameter to determine the vegetation impact from reserve pit fluids is the salt content. These findings support the conclusions of Younkin and Strosher (1980), who state that "high salt content [is] the cause of over 90% of the observed damage. Injury to plants result[s] from contact at the time of the spill by uptake of toxic concentrations.". And again, in a study of six sites drilled in the Canadian Arctic between 1973 and 1976, Smith and James (1980) determined that "[c]hloride had the greatest plant toxicity potential of all the ions measured".

Based on these and other studies, the TDS level in reserve pit fluids below which adverse impacts to vegetation are unlikely is between 2,000 and 4,000 mg/l [Myers and Barker (1984)].

Several factors explain why substantial damage to vegetation in the Arctic from reserve pit fluids has not been found:

Annual Flushing. At Breakup on the North Slope, water drains by sheetflows across the tundra surface. This annual flushing substantially enhances the ability of the tundra environment to adapt or recover from reserve pit discharges. As noted by Younkin and Strosher (1980), "The results of [our] penetration studies indicate that the majority of components from sump fluids applied to topsoil systems are readily removed from the vegetation zone and should cause minimal longterm damage there.".

Experiments conducted in the field demonstrate the importance of the flushing mechanism. Simmons et al. (1983) flooded a wet tundra experimental site in the Prudhoe Bay Field with seawater containing greater than 29,000 mg/l. Conductivity levels of the tundra returned to prespill levels within 30 days. This was "attributed to dilution of the soil water and to the predominance of graminoid vegetation: (characteristic of wet tundra areas).

Soil Saturation. Most spills onto tundra tend to collect in areas of low relief. Standing water tends to accumulate in these areas and provide a buffer between any oily components and plant roots, with only the upper leafy portions of the tundra being affected. For spilled brines, dilution from standing water is the primary mitigative mechanism (Simmons et al. 1983, Barker 1985, McKendrick 1986).

Resiliency of Arctic Flora and Fauna. Species that exist in the Arctic do so because they have adapted to the extremes in environmental conditions to perturbations. Based on an assessment of the impacts to vegetation from 17 abandoned well sites in NPRA, McKendrick (1986) concluded that "there is a plasticity in the Alaskan tundra flora and fauna which provides a capacity for adapting to several commonly occurring disturbances associated with hydrocarbon exploration".

At worst, the acreage adversely affected by reserve pit fluids should be limited to a 50-foot corridor surrounding the reserve pit -- assuming the State of Alaska promulgates its proposed standard requiring compliance with the water quality standards within 50 feet of the exterior toe of the reserve pit wall. Using a typical North Slope well production pad as an example, the work pad and reserve pit together occupy about 30 acres. A 50-foot worst-case impact zone along the reserve pit wall would add less than 2.5 acres to the overall footprint of the production pad. But, regardless of the affected acreage, as demonstrated above, any adverse affects to vegetation from reserve pit fluids are expected to be minimal and short-lived.

In summary, it must be recognized that reserve pit design and construction have been evolving and has been subject to regulatory control from the start. The experience gained over the last 20 years has resulted in both techniques and regulations that will ensure that water quality standards are met.

5. OTHER WASTE HANDLING PRACTICES

Section 2 focussed on the handling of wastes from the drilling process. In Section 3, attention is turned to the management of produced water, other associated wastes, hazardous wastes, solid waste, and sanitary waste. In these areas, the Prudhoe Bay record is exemplary. Problems have been few and far between, and management practices meet or exceed strict state and federal standard.

5.1 Produced Water

As crude oil is processed in SAPC's gathering centers, the natural gas and water in the crude oil are separated. The water removed is termed "produced water" and amounts to about 100,000,000 barrels annually.

Two-thirds of the produced water is recycled into the oil reservoir to help maintain pressure for enhanced oil recovery, while the other one-third is injected below the permafrost. The absence of an underground source of drinking water within the production area of the Prudhoe Bay Unit on the North Slope makes injection of produced water a particularly safe management practice. The Prudhoe Bay Unit area has been exempted from use as a drinking water source under the EPA's Underground Injection Control program. The State of Alaska manages this program for Class II (non-hazardous) injection wells and administers the injection of produced water into these wells.

5.2 Associated Wastes

In addition to drilling fluids and produced waters, oilfield operations generate other wastes including well treatment fluids, spent chemicals used for processing crude oil, rig washwater, hydraulic fluids from rig equipment, cooling waters, etc. (Table 10).

These substances are unique to the production of oil and gas and are exempted from regulation as hazardous waste under the Resource Conservation and Recovery Act. These wastes are termed "associated wastes." Approximately 150,000 barrels of associated wastes were generated by SAPC in the Western Operating Area in 1985.

In the past, non-oily liquid wastes from drilling that are not comingled with produced waters have been removed and transported to Class II (non-hazardous) disposal wells at production facilities or have been discharged to reserve pits. These liquids made up only a small fraction of the total volume of reserve pit liquids, which were removed in the summer by tundra discharge, road watering, and Class II and annular injection. Spent chemicals, cooling waters, and other wastewater from production facilities have been injected in Class II disposal wells at those facilities. Associated wastes high in oil residues and solids have also been handled through a disposal well system that is separate from the production facilities and that is equipped to handle liquids with high solids content. Currently, all associated wastes not comingled with produced water or drilling fluids are being injected into Class II wells.

5.3 Hazardous Waste Management

A small volume of regulated hazardous waste is generated in the production of oil. SAPC has in place a carefully managed program for the reduction of the volume of hazardous waste generated and the on-site recycling, reclamation or treatment of that waste.

In 1986, SAPC generated approximately 300 drums of hazardous waste, the majority of which was used oils. Twenty-six percent of this waste was treated on-site and rendered non-hazardous, while 38 percent was reused as beneficial fuel at a cement kiln operation offsite. Only five percent of SAPC's hazardous wastes generated in 1986 was sent for disposal to a permitted commercial incinerator in the Lower 48.

Ten percent of SAPC's hazardous waste are non-halogenated solvents used for cleaning and lubricating. These solvents are also ignitable but are segregated from the waste oils to improve recycling options. Because they are less toxic, non-halogenated solvents are used in place of chlorinated solvents whenever possible. Halogenated solvents that must be used are segregated from other waste streams.

Currently, no permitted hazardous waste disposal facilities exist in the State of Alaska, and wastes must be shipped out-of state for disposal. Until August 1985, hazardous waste could be injected at the ARCO Pad 3 facility, which was permitted for Class I hazardous waste injection. Underground injection of hazardous wastes is a preferred disposal option on the North Slope due to the lack of underground drinking water sources in the area and the presence of permafrost which provides an additional insurance that injected wastes are confined. The application for the final RCRA permit for this facility is currently under review by the EPA, and the Pad 3 facility now operates under a Class II injection permit for exempt associated wastes.

SAPC maintains a permitted hazardous waste storage facility where wastes are profiled, labeled and packaged for later treatment or off-site shipment. SAPC applied for the permit for this facility in 1980 under the provisions of the Resource Conservation and Recovery Act. Only one notice of violation has ever been received by SAPC for its hazardous waste management. In December of 1983, the EPA issued a notice of violation after a July 1983 inspection of North Slope facilities. The notice addressed procedural infractions such as lack of a closure plan for the storage facility. SAPC immediately provided a copy of the plan and responded to other questions concerning facility boundaries and permit signatures. No fines or subsequent warnings were issued by EPA.

5.4 Handling of Solid and Sanitary Wastes

Solid and sanitary wastes are handled in an environmentally sound manner according to state and federal regulations. Sanitary waste is treated at SAPC's Central Sewage Treatment Facility (CSTF) at Prudhoe, while solid waste is disposed of at an incinerator operated by the North Slope Borough.

Solid Waste. Solid, non-hazardous waste generated by SAPC is handled at the North Slope Borough landfill or incinerator. Combustible materials such as paper products, oily sorbents, wood, and rags are collected and transported to the incinerator, while metals, glass, and other non-combustibles are sent to the landfill. The landfill has been excavated below grade to allow the frozen ground beneath the tundra to create impermeable walls and provide for permanent encapsulation of the wastes.

In addition to solid wastes from camp facilities, operations generate empty drums and barrels that require disposal. Historically, SAPC has handled drum rinsing and crushing operations in-house. For a brief period in 1982, this operation was performed by a North Slope contractor. Today, empty drums are triple-rinsed at SAPC's drum steam-rinsing operation and used for collection of associated wastes in the field. When drums can no longer be used, they are flushed and crushed on-site and sent to the North Slope Borough Landfill for disposal. At first, SAPC processed drums outside in a lined containment area at C Pad. However, this operation could only be run in the summer, and large number of empty drums collected over the winter months. An indoor facility is now used for drum rinsing and crushing operations to allow for year-round operations so that accumulation of empty drums is minimized.

Sanitary Waste. The Central Sewage Treatment Facility (CSTF) is the principal wastewater treatment facility for the Western Operating Area. Small secondary wastewater treatment facilities operated until 1984 at Construction Camp No. 2 and until early 1987 at SAPC's East Dock Exploration Camp.

The central facility is designed to serve a population of 1,500 people based on a flow of 100 gallons per day per person and a sewage strength of 800 mg/l for both biological oxygen demand (BOD_5) and total suspended solids (TSS). At the current population of 450, only one third of the design capacity is being used. The treatment process is capable of meeting EPA effluent standards of 30 mg/l of BOD_5 and 30 mg/l of suspended solids. A laboratory at the central facility monitors the plant effluent daily, and the treated wastewater is discharged to a lake near the Base Operations Center.

The central facility contains the following primary and secondary treatment capabilities: primary screening, trickling filters, extended aeration, clarification, chlorination, sludge conditioning, sludge thickening, and incineration. Tertiary treatment processes at the facility include chemical coagulation, flocculation, clarification, filtration, and carbon absorption. Since effluent limits are easily met with secondary treatment, tertiary treatment is normally not required. The cost to treat wastewater for 450 people is approximately $2,000,000 per year.

The plant is run by a team of operators certified by the State of Alaska in water treatment, and each is required to maintain a Level 3 certificate in wastewater treatment plant operations. An ongoing training program helps insure that the operators retain their certification.

The effluent from the Central Sewage Treatment Facility is regulated by a permit issued to SAPC by the EPA under the National Pollutant Discharge Elimination System (NPDES). Monitoring shows that the effluent is well within the parameters set by the permits. Only one minor exceedance has occurred at the CSTF in the past four years, and relatively few occurred before that. The EPA is immediately notified of any such incident. Table 11 summarizes the data from these incidents back to 1982.

6. MANAGEMENT OF OIL AND CHEMICAL SPILLS

Spills are an inevitable result of the production and transportation of oil. Human errors are not completely avoidable, and not all equipment failures can be prevented. However, measures can be taken to minimize the occurrence of spills, to help insure that spills do not reach the environment, and to clean up any spill that does occur.

Critics of oil development in the Arctic often point to the number of spills reported to Prudhoe Bay and conclude that the environmental impact from these spills has been severe. This misconception results from a lack of understanding of the size and location of these spills, the measures that are taken in response to them, and the spill prevention and containment features that are engineered into facilities used for storing and transferring oil and chemicals. In addition, facilities handling oil and chemicals are covered by strict state and federal regulations. All spills must be reported and appropriate actions taken to clean up and dispose of the spilled material.

6.1 Spill Locations and Statistics

Most spills occur on and are contained by the gravel pads upon which all North Slope facilities are constructed. Since the Prudhoe Bay area is essentially snow-covered and frozen for nearly three-quarters of the year, most of the spills that do occur affect only snow and ice and are easily removed. In fact, snow has been found to be an excellent sorbent material for the removal of oil spills. Contaminated snow and ice are scraped up by front-end loaders or by laborers with shovels and transported to a collection area so that the oil can be later removed. The vast majority of spills never reach the tundra or waterways.

Studies have shown that with proper oil recovery and cleanup techniques, followed by simple restoration procedures, vegetation in tundra areas that are affected by oil can recover as quickly as one summer growing season.

SAPC has tried numerous restoration techniques and has found that tundra areas affected by oil spills (especially moist or wet tundra) usually recover quite well if the area is cleaned of dead vegetation and if fertilizer and seed are applied (McKendrick and Mitchell, 1978; Walker et al., 1978; Webber and Ives, 1978; Chapin and Chapin, 1980; Johnson et al., 1980; Johnson, 1981; Pope and Hillman, 1982; Pope et al., 1982; Brendel, 1985; and McKendrick, 1986).

The large majority of spills are small in volume and are handled relatively easily. As shown in Tables 12 and 13, SAPC reported 569 spills for the period from 1981 through 1986 (these statistics do not include releases from reserve pits, which are listed in Table 2). The vast majority of these spills were less than 100 gallons, and only 81 of these spills actually left the gravel pads. However, many of these were on frozen ground, and in most cases very small areas were affected, most far less than an acre. Recently published statistics from the Alaska Department of Environmental Conservation (ADEC) support the SAPC data. For the entire North Slope of Alaska, ADEC reported a total of 953 spills for the 1985-86, with 93.1 percent (887 spills) less than 500 gallons. Of these 887 spills, 64.7 percent were less than 55 gallons.

Other factors minimizing spills and their effects include spill prevention design in facilities, emphasis on day-to-day good housekeeping practices, and spill contingency planning and training, and restoration practices when spills do occur. All facilities used to store or transfer oil and chemicals are designed with spill prevention in mind. Storage tanks are placed in lined containment areas, and drip pans are used under connections that might be prone to leakage. In addition, all operators develop comprehensive spill contingency plans and stockpile spill response equipment either individually or through cooperative arrangements. SAPC maintains a dedicated staff of spill response personnel in the Western Operating, and this staff is supported by a large inventory of equipment both owned by SAPC and available to SAPC through the cooperative organization Alaska Clean Sea. ACS alone has over $5 million worth of spill response equipment stored at Prudhoe Bay.

6.2 Incidents Receiving Citations

In the past 10 years of operation on the North Slope, SAPC has been cited only three times for oil spills. One incident was associated with drilling of a non-production well during the winter of 1981, and two were associated with offshore exploratory wells. Fines were assessed in these cases, but all three were cleaned up and to the satisfaction of the regulatory agencies involved and in accordance with SAPC company policy. Based on these experiences, new measures were instituted to prevent the release of oil and chemicals to the environment. Subsequent to these spills, SAPC made significant changes in fuel handling and transfer equipment and procedures, including use of better liners for fuel storage areas, the placement of an impermeable liner beneath an entire drilling rig, more efficient use of drip pans at transfer points, and improved employee training. Since 1981, SAPC has received no fines or citations for oil or chemical spills. Brief discussions of these three cases follow.

- Challenge Island (June 1981). Following a winter drilling operation on this tiny natural gravel-and-sand island in the Beaufort Sea, several areas of oil contamination were discovered. The spill was eventually determined to involve approximately 3,000 gallons of diesel fuel and lubricating and hydraulic oils. The cause is believed to have been leaks and spills from fuel handling equipment. An intensive, costly cleanup operation removed the spill, and environmental studies conducted during the cleanup showed that there was no measurable effect. SAPC was fined $3,000 by the U.S. Coast Guard for discharge of oil into navigable waters.

- Tract Well Spills (1981). During the winter of 1981, SAPC drilled four tract wells from existing pads in the far western part of the Prudhoe Bay oilfield. During the breakup that year, spills were discovered on and around the pads. These spills involved drilling muds with some oil content, crude oil, and diesel fuel, with each spill involving approximately 150 gallons of oil. A total of approximately 11 acres of tundra were affected, but they were restored. While the sources of the spills were not clear, SAPC immediately began an extensive cleanup and restoration program to remedy the problem. The Alaska Department of Environmental Conservation fined SAPC $23,546 for violation of state regulations regarding discharge of oil to land of the state. Subsequent monitoring indicated that the affected areas of tundra recovered.

o Sag Delta No. 8. SAPC drilled this exploration well in the winter of 1981 from an artificial gravel island in the Beaufort Sea off Prudhoe Bay. A civil penalty of $250 was levied by the U.S. Coast Guard for a small spill of approximately 1 quart of oil that entered the Beaufort Sea. The oil emanated from gravel where several gallons of oil had been spilled during winter operations. The sheen was removed from the water with sorbents and the contaminated gravel was removed.

7. Conclusion

After many years of study, there is no evidence that petroleum development at Prudhoe Bay has adversely affected any plant or animal species at the community or population level, in terms of productivity, population size, regional distribution, or the ability of habitat to support future growth.

The cooperative commitment by government and industry to avoid and minimize adverse effects of petroleum development on vegetation and wildlife has proven to be remarkably effective. North Slope development does not occur in a regulatory vacuum: every step of oilfield planning and implementation is governed by regulatory permit stipulations and agency scrutiny. As questions or concerns arise, they are appropriately dealt with through field monitoring and scientific research, as well as changes to facility designs, construction practices and operating practices. As a consequence, industry and government are continually developing new ways to improve mitigation and make the investment of knowledge and commitment necessary to protect the environment. This positive trend will govern all future petroleum development on Alaska's Arctic Coastal Plain.

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TABLE 1

SUMMARY OF MAJOR REGULATORY PROGRAMS
GOVERNING NORTH SLOPE OIL AND GAS OPERATIONS

LAW/REGULATION	SUMMARY
	GENERAL PROGRAMS
CLEAN WATER ACT	Section 404, which is administered by the U.S. Army Corps of Engineer, requires a public interest review including an evaluation of the project against the EPA water quality guidelines. The EPA has ultimate veto authority over actions by the Corps under Section 404. The Corps must also receive water quality certification from the state before a 404 permit can be issued.
FISH AND WILDLIFE COORDINATION ACT	Provides for the formal involvement of resource agencies such as EPA, Fish and Wildlife Service, and National Marine Fisheries Service in federal actions such as the Corps 404 permit.
NATIONAL ENVIRONMENTAL POLICY ACT	Requires an environmental impact statement for any "major" project.
ALASKA COASTAL MANAGEMENT PROGRAM	Alaska has developed permitting procedures which provide for a comprehensive state review of projects involving a federal and a state permit, or two or more state permits. Agencies involved include the Departments of Natural Resources, Fish and Game, and Environmental Conservation. The Alaska Division of Governmental Coordination acts as the coordinator for the state review process. The regulations also provide for formal involvement of the affected Coastal Management District. In the case of the North Slope, this district is the North Slope Borough.

TABLE 1 (Cont'd)

LAW/REGULATION	SUMMARY
LEASE OPERATIONS PERMITS	The application requirements for these permits include the preparation of plans describing how the lease will be utilized, construction of facilities will proceed, how various waste streams will be handled, and how the site will be rehabilitated. For state lease activities, the Division of Oil and Gas and the Alaska Oil and Gas Conservation Commission have jurisdiction, while for federal leases, the Bureau of Land Management is the lead agency. In addition, the North Slope Borough's land management regulations require a development permit for oil and gas activities.
DRILLING WASTE MANAGEMENT	
NPDES PERMIT FOR WASTEWATER DISCHARGE TO SURFACE WATERS	The National Pollutant Discharge Elimination System is a permitting system for point-source discharges of wastewater to surface waters of the U.S.
401 WATER QUALITY CERTIFICATION FOR THE NPDES PERMIT	The state must issue a certification that the federal permit would not violate the state water quality standards.
SOLID WASTE DISPOSAL PERMIT	To replace the currently enforced regulations, the State of Alaska has produced new regulations tailored more specifically to the reserve pit drilling fluids disposal issues of Alaska. These new regulations are nearing promulgation and include consideration of the differences created by the presence of permafrost. The focus of the new regulations will be on efficient fluid management practices to reduce the volumes of water in the reserve pit. A more specific monitoring program will be required for the detection of potential seepage problems.

TABLE 1 (Cont'd)

LAW/REGULATION	SUMMARY
AUTHORIZATION FOR DISPOSAL OF DRILLING FLUIDS AND PRODUCED WATER	Water produced from oil and gas wells in Prudhoe Bay is used for enhanced recovery or injected into disposal wells. This activity is subject to regulations under the Safe Drinking Water Act for Class II injection wells (Underground Injection Control Program). The Alaska Oil and Gas Conservation Commission is the lead agency for the State of Alaska for this program, which is administered nationally by the EPA.
	OIL AND CHEMICAL SPILL MANAGEMENT
OIL AND HAZARDOUS SUBSTANCE POLLUTION CONTROL	A spill prevention, control, and countermeasure (SPCC) plan is required for most fuel storage and transfer facilities (40 CFR). The SPCC plan addresses potential sources of oil/hydrocarbon discharges and measures to prevent any discharges from reaching surface water. An oil discharge contingency plan is required for oil terminal facilities, oil tank vessels or barges, offshore exploration or production facility or other facilities (18 AAC 75). In addition, all spills of oil and chemicals must be reported and cleaned up to the satisfaction of various state and federal agencies, including the Alaska Department of Environmental Conservation and the U.S. Coast Guard.
	HAZARDOUS WASTE MANAGEMENT
RESOURCE CONSERVATION AND RECOVERY ACT	EPA regulations under 40 CFR govern all hazardous waste management activities from generation through storage and transportation to ultimate disposal. Currently, the North Slope oil and gas operators, the State of Alaska, and the EPA are negotiating a permit for a Class I injection well for hazardous waste on the North Slope.

TABLE 1 (Cont'd)

LAW/REGULATION	SUMMARY
SOLID AND SANITARY WASTE MANAGEMENT	
CLEAN WATER ACT AND RESOURCE CONSERVATION AND RECOVERY ACT	Guidelines for waste collection, storage, treatment and disposal are addressed by EPA regulations for water quality and solid waste management.
SOLID WASTE DISPOSAL PERMIT	Alaska Department of Environmental Conservation regulations govern solid waste management, set water quality standards, establish wastewater disposal criteria and require water and wastewater treatment plant certification (16 AAC).
WILDLIFE PROTECTION	
FISHERIES AND FISHING REGULATIONS	Alaska Fish and Game Codes have been established to protect fishery resources of the state. On the North Slope, any activity within a fish bearing waterway requires a Title 16 permit.
ENDANGERED SPECIES ACT	The U.S. Fish and Wildlife Service has established regulations to protect endangered and threatened species (16 USC 1531). An environmental assessment or environmental impact statement for an oil and gas activity must address these and NEPA regulatory requirements in regards to protection of these species. A number of other federal acts have been established for wildlife protection and are listed in the appendix.
PERMIT STIPULATIONS	Stipulations for protecting wildlife are often included in permits for development on the North Slope. These stipulations include providing crossing ramps for caribou over pipelines and avoiding waterfowl nesting areas during construction.

TABLE 2

SUMMARY OF STANDARD ALASKA PRODUCTION COMPANY RESERVE PIT INCIDENTS, 1970-1986
(Prudhoe Bay Western Operating Area)

DATE	LOCATION	CAUSE	RELEASE	AREA AFFECTED
6/9/80	C Pad	Wash-out of pit wall	Water w/mud	3 acres
6/1/83	H Pad	Overflow from meltwater	1,000 gal water	500 sq. ft.
8/25/83	R Pad	Seepage from new pit	350 bbl mud	10,000 ft^2
6/15/86	D Pad	Break in pit wall	25,000 bbl water	2 acres
6/24/86	C Pad	Overtopping of pit wall	3,800 yd^3 mud	1.4 acres
10/7/86	F Pad	Leak in pit wall	84 gal water w/oil*	200 ft^2

*Included in spill data in Table 12.

TABLE 3

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION WASTEWATER DISPOSAL LIMITATIONS FOR DEWATERING RESERVE PITS TO TUNDRA

PARAMETER	1984	1985	1986
Salinity (o/oo)	3.0	3.0	3.0
pH (of discharge)*	6 to 9*	6 to 9*	6 to 8.5*
Aromatic hydrocarbons (ug/l)	**	**	10.0
TROG (mg/l)	15.0	15.0	15.0
COD (mg/l)	200.0	200.0	200.0
Settleable solids (ml/l)	0.2	0.2	0.2
Metals (mg/l)			
Aluminum (Al)	NR	**	**
Arsenic (As)	0.050	0.050	0.050
Barium (Ba)	1.000	1.000	1.000
Boron (B)	NR	NR	**
Cadmium (Cd)	0.010	0.010	0.010
Chromium (Cr)	0.050	0.050	0.050
Copper (Cu)	NR	**	**
Lead (Pb)	0.050	0.050	0.050
Manganese (Mn)	0.050	0.050	NR***
Mercury (Hg)	0.002	0.002	0.002
Nickel (Ni)	NR	**	NR***
Silver (Ag)	0.050	NR***	NR***
Zinc (Zn)	NR	**	**
Visible sheen	Not allowed	Not allowed	Not allowed

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* In addition, the pH of the discharge must be with 0.5 of the pH of the receiving water.

** Monitoring required, but no limitation set on concentration.

*** Silver and nickel are not included because they are not found in pit water, while manganese is not included because it is naturally high in water.

NR = Not required
TROG = Total recoverable oil and grease
COD = Chemical oxygen demand

TABLE 4

NUMBER OF EXCEEDANCES OF DISCHARGE REQUIREMENTS FOR STANDARD ALASKA PRODUCTION COMPANY RESERVE PIT DEWATERING
(Prudhoe Bay Western Operating Area)

	NUMBER OF EXCEEDANCES		
PARAMETER	1984	1985	1986
Metals (mg/l)			
Arsenic (As), 0.05	18	0	0 (1)*
Barium (Ba), 1.00	6	0	3
Cadmium (Cd), 0.01	3	0	0
Chromium (Cr), 0.05	8	1	2 (3)*
Lead (Pb), 0.05	1	1	0 (1)*
Manganese (Mn), 0.05	24	3	0**
Mercury (Hg), 0.002	1	0	0
Silver (Ag), 0.05	1	0**	0**
Salinity	21	8	2
pH	2	2	0
Aromatic HC	0	0	0
TROG	1	0	0
COD	8	1	1
Settleable solids	5	0	0

*Number in parenthesis was prior to revised laboratory information regarding a decimal point error in reporting these values.

**Monitoring not required

HC = Hydrocarbons
TROG = Total recoverable oil and grease
COD = Chemical oxygen demand

TABLE 5
SUMMARY OF SAPC RESERVE PIT DISCHARGE DATA
(1984 - 1986)

PARAMETER	ALASKA WATER QUALITY CRITERIA (mg/l)	RESERVE PIT DISCHARGE DATA (mg/l)				
		MINIMUM	MAXIMUM	MEAN	MEDIAN	NUMBER OF SAMPLES
Arsenic (As)	0.05	0.002	1.3	0.172	0.033	40
Barium (Ba)	1.00	0.01	17.4	1.09	0.50	38
Cadmium (Cd)	0.010	<0.001	0.017	0.004	0.001	38
Chromium (Cr)	0.050	0.0002	0.750	0.079	0.010	40
Manganese (Mn)	0.050	0.028	1.000	0.202	0.097	35
Mercury (Hg)	0.002	<0.0001	0.007	0.0008	0.0002	39
Lead (Pb)	0.050	<0.001	0.148	0.024	0.012	40
Silver (Ag)	0.050	<0.001	0.112	0.015	0.001	29

TABLE 6

1984 STANDARD ALASKA PRODUCTION COMPANY
MONITORING DATA FOR RESERVE PIT DEWATERING

DATE 1984	LOCATION (Pad/Pit)	SALINITY (o/oo)	pH	Arom/HC ppb	TROG mg/l	COD mg/l	SS ml/l	VOLUME bbl	FREE OIL no/yes	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
6/08	A/NE	0	-		-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/10	A/NE	-		-	-	-		-	-	0.005	-	0.016	-	0.4	0.001	0.001	-	0.0002	0.040	-	0.003	-
6/11	A/NE	-	6.9	<1	0.8	32	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/14-8/12	A/NE	-		-	-	-	-	30500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/11	A/NE	2.0	8.1	<1	20.1	72	0	-	no	0.002	-	0.089	-	0.64	0.001	0.002	-	0.007	0.098	-	0.012	-
8/12	A/NE	2.2	8.7	-	-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	A/C	0		-	-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/10	A/C		-		-		-		-	<0.001	-	0.117	-	0.60	0.017	0.008	-	<0.0001	0.067	-	0.008	-
6/11	A/C	-	8.0	<1	1.0	142	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/11-7/25	A/C		-		-		-	59000	-	-	-	-	-	-	-	-		-	-	-	-	-
7/25	A/C	5.4	7.8	<1	2.4	234	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	B/SE	0	-		-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/12	B/SE	1	6.6	<1	0.1	33		-	-	<0.001	-	0.022	-	0.9	0.001	0.002	-	<0.0001	0.113	-	0.002	-
8/08	B/SE	2.99	9.3	<1	0.3	66	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/08	B/SE	-		-	-	-	-	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/24	C/NW	2.4	-		-	-	0.5	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/25	C/NW	-		-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9/01	C/NW	1.6	8.3	-	1.2	112	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9/02	C/NW	1.2	8.4	-	0.6	116	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9/03	C/NW	3.5	8.5	-	0.2	112	0	-	-	0.002	-	0.018	-	1.49	0.002	0.002	-	0.002	0.097	-	0.006	-
9/01-9/03	C/NW	-		-		-	-	22700	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	D/NE	0	-		-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/11	D/NE	-	6.8	-	0.6	33	-	-	-	0.007	-	0.034	-	0.3	0.001	0.0002	-	0.0001	0.098	-	0.004	-
6/12	D/NE	-	-	<1	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/10	D/NE	0.4	-	-	-	-	0.05	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/11	D/NE	4.8	-		-	-	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/12	D/NE	3.8	-		-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/13	D/NE	2.8	-		-	-	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/11-7/14	D/NE	-		-	-	-	-	97200	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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TABLE 6 (Cont'd)

1984 STANDARD ALASKA PRODUCTION COMPANY
MONITORING DATA FOR RESERVE PIT DEWATERING

DATE 1984	LOCATION (Pad/Pit)	SALINITY (o/oo)	pH	Arom/HC ppb	TROG mg/l	COD mg/l	SS ml/l	VOLUME bbl	FREE OIL no/yes	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
6/08	D/NW	1.1		-	-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/11	D/NW	-	7.1	-	0.8	73	0		-	0.001	-	0.044	-	0.5	0.001	0.023	-	<0.001	0.033	-	0.004	-
6/12	D/NW		-	<1	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/10	D/NW	0		-	-	-	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/11	D/NW	2.2		-	-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/12	D/NW	4.2		-	-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/13	D/NW	3.0		-	-	-	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/10-7/14	D/NW		-		-		-	98000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	E/N	0.7	-		-	-	0.175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/06	E/N	-		-	-	-		-	-	0.001		0.212		0.6	0.004	0.170	-	<0.0001	0.064	-	0.015	-
7/13	E/N	4.5	-		-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/14	E/N	3.9	-		-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/15	E/N	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/16	E/N	4.2	-		-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/05	E/N	4.1	7.7	2	0.5	410	TR		-	0.002	-	0.321	-	0.20	0.001	0.195	-	0.002	0.150	-	0.018	-
7/13-8/05	E/N	-		-	-	-	-	84000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	E/S	0.7	-		-	-	0	-	-	<0.001	-	0.019	-	0.44	0.009	0.003	-	<0.0002	0.064	-	0.004	-
7/06	E/S	-		-	-	-		-	-	0.001	-	0.050	-	0.7	0.001	0.003	-	0.0003	0.042	-	0.004	-
7/19	E/S	2.0	7.5	1	1.3	105	0	-	-	<0.001	-	0.019	-	0.44	0.009	0.003	-	<0.0002	0.064	-	0.004	-
7/19	E/S	3.2	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/20	E/S	2.5	-		-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/21	E/S	1.6	-		-	-	0		-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/22	E/S	2.4	-		-	-	0		-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/23	E/S	19	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/19-7/23	E/S	-		-	-	-	-	6000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	F/W	1.2	-		-	-	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/27	F/W	2.5	6.9	-	0.3	60	0		-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/28	F/W	2.8	-		-	-	0		-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/29	F/W	2.9	7.4	<1	0.6	61		-	-	0.002	-	0.462	-	1.2	<0.001	0.004	-	<0.0002	0.48	-	0.148	-
7/30	F/W	1.8	-		-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/31	F/W	2.94	7.4	1.1	0.5	259	0	-	-	0.002	-	0.443	-	1.74	<0.001	0.001	-	0.0003	0.047	-	0.007	-
8/01	F/W	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/02	F/W	3.3	7.2	-	0.9	57	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03	F/W	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/04	F/W	2.42	7.4	-	0.5	64	TR	-	-	0.001	-	0.364	-	0.39	0.013	<0.001	-	0.007	0.064	-	0.009	-
7/27-8/04	F/W		-		-		-	152000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6 (Cont'd)

1984 STANDARD ALASKA PRODUCTION COMPANY
MONITORING DATA FOR RESERVE PIT DEWATERING

DATE 1984	LOCATION (Pad/Pit)	SALINITY (o/oo)	pH	Arom/HC ppb	TROG mg/l	COD mg/l	SS ml/l	VOLUME bbl	FREE OIL no/yes	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
6/08	G/N	1.3	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/14	G/N	8.2	-	-	-	-	1.5	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/15	G/N	6.4	-	-	-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/16	G/N	1.6	-	-	-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/17	G/N	0.9	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/18	G/N	3.9	8.0	2	1.0	164	TR	-	no	<0.001	-	0.019	-	1.50	0.010	0.015	-	<0.0002	0.150	-	0.026	-
7/19	G/N	3.9	-	-	-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/15–7/20	G/N	-	-	-	-	-	-	138700	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/09	N/SE	0	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/26		-		-	-	-	-	6000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/09	J/SE	0		-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/06	J/SE	2.6	7.5	-	0.9	82	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/08	J/SE	2.7	7.3	<1	0.4	82	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/09	J/SE	2.5	6.6	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/10	J/SE	1.0	6.6	-	1.0	55	TR	-	no	0.004	-	0.252	-	0.76	0.001	0.003	-	0.0007	0.977	-	<0.001	-
8/06–8/10	J/SE	-	-	-	-	-	-	81500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/10	N/SW	2.6	8.4	-	2.0	111	TR	-	no	0.003	-	0.216	-	0.52	0.003	0.016	-	0.001	0.480	-	0.012	-
8/11	N/SW	2.6	8.6	<1	-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/10–8/12	N/SW		-	-	-	-	-	49000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/09	N/S	0.6	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/10	N/S	1.7	8.8	<1	0.7	166	TR	-	no	0.003	-	0.107	-	0.05	0.002	0.008	-	0.001	0.426	-	0.021	-
8/10–8/11	N/S		-	-	-	-	-	23500	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6 (Cont'd)

1984 STANDARD ALASKA PRODUCTION COMPANY
MONITORING DATA FOR RESERVE PIT DEWATERING

DATE 1984	LOCATION (Pad/Pit)	SALINITY (o/oo)	pH	Arom/HC ppb	TROG mg/l	COD mg/l	SS ml/l	VOLUME bbl	FREE OIL no/yes	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
6/09	Q/C	0.6	-	-	-	-	0	-	-	<0.001	-	0.032	-	1.2	0.001	0.001	-	<0.0001	0.053	-	0.001	-
7/07	Q/C	1.2	7.8	-	0.8	30	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/16	Q/C	0.6	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/17	Q/C	0.9	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/16–7/18	Q/C	-	-	-	-	-	-	3200	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/06	Q/C	1.0	7.5	-	0.5	48	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/07	Q/C	1.2	7.6	-	0.8	36	TR	-	no	0.001	-	0.270	-	0.13	0.014	0.001	-	<0.0002	0.089	-	<0.001	-
8/08	Q/C	1.3	9.3	-	-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/09	Q/C	1.0	7.1	<1	1.0	55	TR	-	no	0.003	-	0.066	-	0.035	-	0.002	-	0.0001	0.474	-	0.017	-
8/10	Q/C	1.0	7.6	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/05–8/10	Q/C				-		-	7600	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	R/NE	0.7	-	-	-	-	0.18	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/12	R/NE	-	7.5	<1	0.9	318	-	-	-	0.001	-	0.151	-	0.2	0.001	0.395	-	<0.0001	1.0	-	0.029	-
7/25	R/NE	8.0	7.8	<1	1.9	740	TR	-	-	0.002	-	1.3	-	-	<0.001	0.75	-	<0.002	0.043	-	0.011	-
7/26	R/NE	6.3		-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/25–7/27	R/NE	-		-	-	-	-	42500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/08	X/S	0	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/06	X/S	-		-	-	-	-	-	-	0.112	-	0.106	-	0.8	0.001	0.270	-	0.0001	0.063	-	0.006	-
7/18	X/S	3.2	8.0	1	0.1	64	0	-	-	<0.001	-	0.031	-	0.28	0.009	0.026	-	<0.0002	0.061	-	0.007	-
7/19	X/S	3.2	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/21	X/S	1.6	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/18–7/22	X/S	-		-	-	-	-	112500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/09	Y/S	0.6	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/29	Y/S	1.8	7.8	<1	2.8	201	TR	-	-	0.004	-	0.801	-	1.4	<0.001	0.25	-	<0.0002	0.262	-	0.037	-
7/30	Y/S	1.8	-	-	-	-	TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/31	Y/S	1.78	7.8	9	2.2	68	TR	-	-	0.001		0.819		0.75	0.001	0.36		0.0002	0.29	-	0.034	-
8/01	Y/S	1.82	7.8	-	1.8	238	TR		-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03	Y/S	1.94	7.6	-	2.3	266	TR	-	-	0.001	-	0.381	-	0.01	0.002	0.235	-	<0.0002	0.301	-	0.026	-
7/29–8/03	Y/S	-	-	-	-	-	-	124000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7

1985 STANDARD ALASKA PRODUCTION COMPANY
MONITORING DATA FOR RESERVE PIT DEWATERING

DATE 1985	LOCATION (Pad/Pit)	SALINITY (o/oo)	pH	Arom/HC ppb	TROG mg/l	COD mg/l	SS ml/l	VOLUME bbl	FREE OIL no/yes	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
8/08	D/SE	2.9	8.6	<1	0.2	60	TR	-	no	-	1.9	0.008	-	0.39	0.002	0.014	0.013	0.0005	0.036	0.031	0.068	<5
8/09	D/SE	3.3	8.3	<1	2.8	65	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/10	D/SE	4.3	-		-	56	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/08-8/10	D/SE	-		-	-	-	-	46500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/19	F/E	4.6	8.0	<1	3.7	270	TR	5000	no	-	0.35	0.005	-	0.27	0.002	0.115	0.013	0.0013	0.22	0.062	0.03	2.1
8/17	G/N	2.2	8.2	<1	1.0	127	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/18	G/N	3.5	8.7	-	2.2	122	0	-	no	-	2.60	0.005	-	0.33	0.001	0.012	0.019	0.0001	0.048	0.043	0.03	0.062
8/17-8/19	G/N		-	-	-		-	45400	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03	J/E	1.6	7.8	-	0.02	84	0	-	no	-	0.252	0.002		0.49	<0.001	0.007	0.013	0.00193	0.432	0.043	0.03	0.092
8/04	J/E	4.6	7.9	<1	2.0	63	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03-8/05	J/E		-		-		-	2700	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/12	N/Mid	2.2	7.9	-	1.4	141	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/13	N/Mid	3.2	7.9	<1	2.1	143	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/14	N/Mid	1.7	7.9	-	3.4	157	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/16	N/Mid	8.2	7.9	-	2.2	160	0	-	no	-	3.00	0.009	-	0.5	0.002	0.045	0.026	0.0015	0.12	0.003	0.009	0.58
8/18	N/Mid	2.2	7.7	-	5.1	169	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/12-8/19	N/Mid		-		-		-	8800	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03	Q/Main	2.1	7.9	-	0.02	46	0	-	no		0.352	0.004	-	0.13	<0.001	0.002	0.006	0.00107	0.028	0.017	0.010	0.032
8/04	Q/Main	3.3	7.9	<1	2.2	28	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03-8/05	Q/Main	-		-		-	-	2700	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 8

1986 STANDARD ALASKA PRODUCTION COMPANY
MONITORING DATA FOR RESERVE PIT DEWATERING

DATE 1986	LOCATION (Pad/Pit)	SALINITY (o/oo)	pH	Arom/HC ppb	TROG mg/l	COD mg/l	SS ml/l	VOLUME bbl	FREE OIL no/yes	Ag ppm	Al ppm	As ppm	B ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Mn ppm	Ni ppm	Pb ppm	Zn ppm
7/04	A/SW	2.2	7.8	-	2.2	157	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/05	A/SW	2.2	8.0	-	1.5	155	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/06	A/SW	7.4	7.6	-	0.7	161	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/07	A/SW	2.5	7.6	-	1.9	161	0	-	no	-	0.043	<0.025	0.42	0.4	0.005	0.090	0.025	<0.0005	-	-	<0.010	0.014
7/04- 7/07	A/SW		-		-	-	-	29800	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/29	D/SE	0.7	7.4		-	70	TR	-	no	-	-	0.004	-	-	-	0.006	-	-	-	-	0.012	-
6/30	D/SE	1.3	-	-	-	-	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/01	D/SE	4.1	8.3		-	82	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/02	D/SE	1.0	8.2	-	-	89	TR	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
6/29- 7/02	D/SE	-		-	-	-	-	49300	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/08	F/E	1.9	7.9	-	4.0	120	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/09	F/E	2.3	8.0	-	2.9	103	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/10	F/E	2.0	7.5	-	1.2	107	0	-	no	-	-	-	-	-	-	-	-	-	-	-	-	-
7/11	F/E	2.0	7.9	-	2.6	246	0	-	no	-	0.014	<0.025	9.60	1.32	0.006	0.053	<0.01	<0.0005	-	-	<0.01	<0.005
7/08- 7/11	F/E	-		-	-	-	-	34500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/26	ED/#2	1.0	7.6	-	1.1	173	0	14500	no	-	0.50	0.005	0.41	2.07	0.001	0.02	0.001	0.0009	-	-	0.006	0.014
8/28	ED/#3	0.8	7.8	-	1.9	129	0.2	-	no	-	0.68	0.008	0.21	17.4	0.001	0.034	0.006	<0.0001	-	-	0.012	0.079
8/28- 8/29	ED#3	-		-	-	-	-	24000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 9

STANDARD ALASKA PRODUCTION COMPANY
PRUDHOE BAY PRODUCTION LABORATORY ANALYTICAL PROCEDURES

PARAMETER	INSTRUMENT	DETECTION LIMIT (ppm)	LOWEST STANDARD USED (ppm) 1984	1985	1986	METHODS
Silver (Ag)	AA-GF	0.000005	0.002	0.010	—	272.2*, 304**
Aluminum (Al)	AA-GF	0.0001	—	0.010	0.010	202.2*, 304**
Arsenic (As)	AA-GF	0.0002	0.025	0.025	0.025	206.2*, 304**
Boron (B)	ICP	0.004	—	--	1.0	200.7*, 305**
Barium (Ba)	AA-GF ICP	0.00004 0.0002	0.05	0.05	1.0	208.2 (1984-85)*, 200.7 (1986), 305**
Cadmium (Cd)	AA-GF	0.000003	0.002	0.002	0.002	213.2*, 304**
Chromium (Cr)	AA-GF	0.0001	0.010	0.010	0.010	218.2*, 304**
Copper (Cu)	AA-GF	0.0002	0.010	0.010	0.010	220.0*, 304**
Mercury (Hg)	AA-ACV	0.00003	0.001	0.001	0.001	245.2*, 303 F**
Manganese (Mn)	AA-GF	0.0002	0.010	0.010	0.010	243.2*, 304**
Nickel (Ni)	AA-GF	0.0001	—	0.010	--	220.2*, 304**
Lead (Pb)	AA-GF	0.00005	0.010	0.010	0.010	239.2*, 304**
Selenium (Se)	AA-GF	0.0005	0.025	0.025	—	270.2*, 304**
Zinc (Zn)	AA-GF	0.000001	0.010	0.010	0.010	289.2*, 304**
COD	—	--	--	--	--	410.1*, 508 B**
pH	—	—	—	--	—	150.1*, 423**
Settleable Solids	—	—	—	--	—	160.5*, 209 E**
Salinity	--	—	—	--	—	210 A, B, and C**
TROG	—	—	—	—	--	413.2*, 503 B**

* Methods for Chemical Analysis of Water and Wastes. EPA Publication 600
** Standard Methods for the Examination of Water and Wastewater. 16th edition.

AA = Atomic absorption spectrophotometer with graphite furnace (GF) and automated cold vapor accessory (ACV)
ICP = Inductively coupled plasma arc spectrophotometer
COD = Chemical oxygen demand
TROG = Total recoverable oil and grease

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TABLE 10
ASSOCIATED WASTES AND HANDLING PRACTICES
(Prudhoe Bay Western Operating Area)

WASTE STREAM	HANDLING PRACTICE
Rig washdown water	Reserve pit
Pigging trap solids	Recycle through production stream
Waste lubricating oils, hydraulic fluids from drilling equipment (non-RCRA hazardous)	Recycle through production stream
Waste crude oil (liquids)	Recycle through production stream
Waste solvents (non-RCRA hazardous)	Recycle through dirty water production system -Class II disposal
Untreated emulsions	Class II disposal
Cooling waters, engine waters, wastewaters	Class II disposal
Workover fluids (spent acid rinsates, wastewaters)	Reserve pit
Bottoms from dirty water tanks	Class II disposal
Oily debris (sorbents, rags)	North Slope Borough solid waste incinerator
Oily gravel, dirt (from spill cleanup)	North Slope Borough landfill

TABLE 11

STANDARD ALASKA PRODUCTION COMPANY
SUMMARY OF NPDES* PERMIT EXCURSIONS, JANUARY 1982 to JUNE 1987

(Prudhoe Bay Western Operating Area Treatment Facilities at East Dock, CC-2 and CSTF)

DATE	UNIT	TYPE OF EXCURSION	PERMITTED LIMIT
1987		NO EXCURSIONS	
1986			
July	CSTF	pH of 9.1	9.0
1985		NO EXCURSIONS	
1984			
Jan	CC-2	BOD of 62 mg/l	60 mg/l
Feb	CC-2	Fecal coliform of 2400 per 100 ml	800 per 100 ml
1983			
Mar	E. Dock	Fecal coliform-contaminated sample	
Jun	E. Dock	Fecal coliform too numerous to count	800 per 100 ml
Jun	CSTF	Suspended solids of 61 mg/l	60 mg/l
Aug	CSTF	BOD of 97 mg/l	60 mg/l
Aug	CSTF	Suspended solids of 60 mg/l	60 mg/l
1982			
Apr	CSTF	Fecal coliform-contaminated sample	
Jul	CSTF	pH of 5.8	6.0
Dec	CSTF	pH of 9.8	9.0

NOTE: CSTF = Central Sewage Treatment Facility
CC-2 = Construction Camp 2

*National Pollutant Discharge Elimination System

TABLE 12

STANDARD ALASKA PRODUCTION COMPANY
OIL AND CHEMICAL SPILLS: ONSHORE PRODUCTION
(Prudhoe Bay Western Operating Area)

NOTE: These spills are for only Standard Alaska Production Company production operations in the Prudhoe Bay Western Operating Area. Non-production spills are given in Table 13.

	NUMBER OF SPILLS					
	1981	1982	1983	1984	1985	1986
Size of Spills						
0-10 gallons	41	57	28	25	20	22
11-20 gallons	16	12	16	12	12	12
21-50 gallons	15	14	27	19	24	21
51-100 gallons	5	9	10	1	6	11
101-200 gallons	5	8	6	9	10	5
201-1,000 gallons	8	2	4	7	8	6
Greater than 1,001 gallons	--	--	--	2	1	1
TOTALS	90**	102	91	75	81	78
Location of Spills						
On Pads	84	91	79	69	76	69
Off Pads	8	11	12	6	5	9
TOTALS	92	102	91	75	81	78
Substances Spilled						
Crude Oil	32	33	20	36	24	32
Diesel Fuel	22	28	23	5	13	11
Mixed Oils; Refined Products	27	26	15	13	9	21
Glycols	2	6	24	15	25	9
Methanol	--	--	--	3	4	2
Other Chemicals	6	7	8	3	3	-
Other	3	2	1	--	3	3
TOTALS	92	102	91	75	81	78
Summary Statistics	Spill Volume (gallons)					
Total Volume	7,507	3,870	4,732	12,600	7,279	6,348
Spill Size Median	15	10	25	20	30	25
Average Spill Size	83	38	52	168*	90	81

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* Includes spills of 2,520 and 5,250 gal. Without these, average is 66.

** Does not include two spills of unknown quantity.

TABLE 13

OTHER STANDARD ALASKA PRODUCTION COMPANY
NORTH SLOPE OIL AND CHEMICAL SPILLS

NOTE: These spills include both onshore and offshore operations on the North Slope, including the construction phase of the Endicott Development Project (1986).

	NUMBER OF SPILLS					
	1981	1982	1983	1984	1985	1986*
Size of Spills						
0-10 gallons	4	4	5	1	1	6
11-20 gallons	1	-	1	-	1	5
21-50 gallons	2	-	1	-	3	3
51-100 gallons	2	1	1	1	-	-
101-200 gallons	1	2	-	1	-	-
201-1,000 gallons	-	-	-	1	-	1
Greater than 1,001 gallons	1	-	-	-	-	-
TOTALS	11	7	8	4	5	15*
Location of Spills						
On Pads	4	6	3	2	4	15
Off Pads	7	1	5	2	1	-
TOTALS	11	7	8	4	5	15*
Substances Spilled						
Crude Oil	3	-	1	-	4	3
Diesel Fuel	2	5	1	3	1	4
Mixed Oils; Refined Products	5	2	6	1	-	2
Glycols	-	-	-	-	-	5
Other	1	-	-	-	-	1
TOTALS	11	7	8	4	5	15*
Summary Statistics	Spill Volume (gallons)					
Total Volume	3,409	428	131	591	159	1,075
Spill Size Median	30	10	10	-	42	20
Average Spill Size	310	61	16	148	32	72

* 1986 spills are from construction of the Endicott Development.

OIL/CHEMICAL SPILLS INFORMATION

SPILL PREVENTION AND CONTINGENCY PLANNING IN THE ARCTIC

- Prevention features like blowout preventers and automatic shutoff valves are designed into wells and facilities in the Arctic during construction.
- Government enforced safe operating procedures required at all facilities.
- Routine inspection, maintenance and security occur at all facilities.
- Spill prevention and response training are required of all operations personnel.
- A spill contingency and response organization is supported by member oil companies to provide training, equipment and response to spill emergencies at North Slope facilities.

INDUSTRY SUPPORTED SPILL RESPONSE COOPERATIVES

- Industry spill plans and equipment stockpiles are arranged by both individual companies and through cooperatives.
- Alaska Clean Seas, an oil spill cooperative, has over $5 million worth of spill response equipment stored at Prudhoe Bay.

LOCATION OF SPILLS

- Great majority of spills never reach the tundra or water.
- Most spills occur in facilities or on gravel pads and roads.
- Tundra frozen and covered by ice and snow nine months of the year prevents damage to vegetation and facilitates spill clean-up.

CLEANUP AND DISPOSAL

- All spills are immediately contained, cleaned up and disposed of properly under regulatory agency supervision.
- Recovered spill material is incinerated or otherwise disposed of with state approval on a case-by-case basis.
- Recovered fluid is recycled in production system where feasible.

SPILL STATISTICS

- No blowouts or major operational spills have occurred on the North Slope or in the Alaskan Beaufort Sea in Prudhoe Bay's history. (Major spill over 1000 barrels, MMS & USCG)
- Standard Alaska Production Company reported the following statistics for oil and chemical spills in the Western Operating Area of Prudhoe Bay during the years 1981 through 1986:
  - SAPC reported a total of 569 oil/chemical spills in this period.
  - The average spill size was less than 100 gallons.
  - The median spill size was 10 to 40 gallons.
  - Only 81 of 569 spills affected small areas off the gravel pads.
  - The total estimated gallons of oil or chemicals spilled off pads during the six year period was 3,240 to 8,100 gallons (This range calculated using the most frequently occurring spill size as the lower end of the range and the maximum average spill size as the upper end of range.)
- To show comparison with ADEC data compiled for the Northern Region from 1985 through 1986, ADEC reported 64.7% of all oil/chemical spills were less than 55 gallons in size.

RESTORATION

- Vegetation restoration procedures have been applied successfully on the North Slope.
- Tundra areas contaminated by oil/chemical spills (especially moist or wet tundra) have recovered in as little as one growing season when the area is cleared of dead vegetation, flushed, aerated, fertilized and seeded.
- Speed and success of tundra recovery is positively correlated with an increase in the moisture level of the area affected. Most spills that reached the tundra accumulated in areas of low relief and high moisture content.
- Alaska flora and fauna demonstrate a certain plasticity which provides a capacity for adapting to several commonly occurring disturbances associated with hydrocarbons. (USGS report for wellsite cleanup on the National Petroleum Reserve-Alaska, 1986)
- "Drilling muds eventually become overgrown by plants; salinity diminishes; and impoundments and thermokarst depressions are colonized by water-tolerant vegetation, if water depths are not too deep." (USGS report for wellsite cleanup on the National Petroleum Reserve-Alaska, 1986)

EFFECTS OF PETROLEUM DEVELOPMENT ON CALVING CARIBOU IN THE ANWR COASTAL PLAIN

Concern about the potential effects of petroleum development on caribou in the ANWR Coastal Plain has focussed on calving of the Porcupine caribou herd. The Draft Legislative Environmental Impact Statement (LEIS) identified an area, termed the "core calving area", where concentrated calving had occurred in 5 to 9 of the 14 years for which there were data. The Draft LEIS predicted that there could be a "major population decline and change in distribution of 20 to 40 percent", largely as a consequence of oilfield development in the "core calving area".

The term "core calving area" implies three things: (1) that the area was used by a higher density of caribou than occurred elsewhere, (2) that the area was used every year, and (3) that it was used by the majority of calving caribou. However, the "core calving area" defined in the Draft LEIS possessed none of these attributes. Calving densities as high or higher occurred outside the "core" area. It is not used every year. In those years when it was used and when there were quantitative data, the majority calved elsewhere.

In the Final LEIS, the concept of a "core calving area" was removed because of its misleading implications. However, this concept has continued to exist in the minds of some. The following discussion describes some of the features of Porcupine herd calving and the information available on the response of calving caribou to oilfield development.

DISTRIBUTION OF CALVING

The Porcupine herd does not consistently use a single, fixed location for calving from year to year. Calving usually takes place in that part of the coastal plain which extends from the Canning River on the western boundary of ANWR to the Babbage River in the Yukon Territory, Canada. This area extnds about 200 miles from east to west and 20 to 40 miles inland from the coast. Calving concentrations for the Porcupine herd vary annually in number and location. In some years, calving takes place mostly in the Yukon, in other years mostly in Alaska, and in other years more-or-less equally split between the two (Fig. 1). In a few years there may be no recognizable concentrations.

The cause of this variability is not clear, but it may be related to snow conditions (Lent 1980). For example, in 1987, on 2 June, just a few days prior to the peak of calving, the majority of the caribou on the calving grounds were on the Yukon coastal plain, where snow cover was considerably less than on the Alaska coastal plain.

DENSITY OF CARIBOU IN CALVING CONCENTRATIONS

The location and extent of concentrations of calving caribou were determined subjectively by biologists based on data collected during aerial surveys. These surveys have been made without objective density criteria since the initiation of studies by the Fish and Wildlife Service in 1982, as well as in preceding years. Since 1983, radio-collared females have been used to provide the basis for quantitative density calculations (G. Elison, USFWS, 19 May 1987). However, the densities were always calculated after the calving concentrations were mapped. They were used to describe the density of caribou within the concentrations, but were never used as objective criteria to define a concentration.

The Final LEIS states that the observed densities in calving concentrations varied from 46-128 caribou/sq. mi. (p. 24), a figure that is made up of mainly cows and newborn calves plus a few yearlings (less than 3%). More recently, however, it has been learned that the minimum density was 33 caribou/sq. mi. (G. Elision, USFWS, 19 May 1987). These figures translate to cow densities of 17-69/sq. mi., or 38 to 9 acres per cow.

As can be seen from these density figures, cow caribou on the calving grounds are not on average particularly crowded, although they may be more densely aggregated in smaller areas within the larger concentration area. It is likely that for many people the term "calving concentration" brings to mind the spectacularly dense post-calving aggregations that form in late June and early July, well after calving. In comparison, caribou are dispersed during calving.

PROPORTION OF CALVING IN THE 'CORE AREA'

The data necessary to compute the proportion of calving within the "core area" are available for only two years, 1983 and 1984 (G. Elison, USFWS, 19 May 1987); 1985 and 1986 data are considered preliminary and are not yet available. In 1983, there was an extensive concentration in the Jago River area, which contained 30% of the radio-collared females (Fig. 2a). One-half of the Jago concentration fell within the "core calving area" as defined in the Draft LEIS. Thus, it can be estimated that in 1983, 15% of calving caribou, as indicated by the distribution of radio-collared females, were within the "core calving area". The density of cows within the "core area" was 17/sq. mi., or one cow per 38 acres.

In 1983, there was a second calving concentration which straddled the Alaska-Yukon border (Fig. 2b). The areal extent of the concentration was much less than that near the Jago River, although the number of radio-collared females (7 of 23) was the same in each. The density of cows within this area was 42/sq. mi., or one cow per 15 acres. Thus, the Alaska-Yukon concentration contained about 2.5 times the density of calving caribou that was observed in the "core calving area".

In 1984, there were three concentrations of calving caribou (Fig. 2b). One of these included part of the "core calving area" and contained a total of 6 of 31 (19%) radio-collared females. That part of the concentration in the "core area" contained about 7% of calving, based on the occurrence of radio-collared females. Additional calving females were scattered in part of the "core area", and this might have increased the percentage by up to 3% for a total of perhaps 10% within the "core area". The densities within the three concentrations, from west to east, were 50/sq. mi., 42/sq. mi., and 27/sq. mi., or 13, 15, and 24 acres per cow, respectively. In 1984, nearly half (48%) calved outside of any concentration.

Our knowledge of the preliminary information from more recent years suggests that a somewhat larger proportion of the cows may have used the "core area" in 1985 than in 1983 or 1984, but that the proportions in 1986 and 1987 were similar to those seen in 1983 and 1984.

The quantitative information about use of the so-called "core calving area" challenges three important implications of the concept. First, the majority of pregnant cows do not calve within the "core area". Second, the average density of calving caribou is not necessarily greatest within the "core area". Third, with densities ranging from 17 to 19 cows/sq. mi. , caribou on the calving grounds, even in concentrations, are not particularly crowded on average.

RESPONSE OF CALVING CARIBOU TO PETROLEUM DEVELOPMENT

Concern about the effects of petroleum development on the Porcupine caribou herd have centered on the potential response of calving caribou, mainly those using the so-called "core calving area". This concern exists despite the acknowledged success of the Central Arctic Herd in the presence of oilfield development. The belief that calving Porcupine herd caribou might react negatively to oilfield development, in contrast to Central Arctic herd aribou in the Prudhoe Bay region, is based on the perception that Porcupine caribou are "much more crowded" in their calving concentrations (DOI 1987, p. 119). There are two things wrong with this argument: first, the Porcupine caribou are not crowded on their calving grounds, and second, there is no known reason why differences in calving density should be of consequence. For reasons discussed earlier, the Porcupine caribou are hardly crowded, even in their concentrated calving areas.

Although it is implied that the Porcupine caribou will suffer some sort of increased impact because of the above-mentioned densities on the calving grounds, the authors of the Final LEIS fail to give any reason for this greater effect. The report correctly states (p. 24) that the important thing is for the calves to be born in an area where they can avoid predation. There is no reason why they would not avoid predation if oilfield infrastructure were also present on the calving grounds.

The best documented study of the effects of oilfield development on calving caribou is that conducted by Dau and Cameron (1986). For four years prior to development (1978-1981) and four years after development (1982-1985) they recorded the distribution of calving caribou in relation to oilfield infrastructure near Milne Point. Following development, they found that there was decreased use of the area within 2 km. (1.2 mi.). From 2-5 km. (1.2-3.0 mi.) there was no statistically significant difference in the number of caribou, but there was a statistically significant increase in the number of caribou using the 5-6 km. (3.0-3.6 mi.) interval. While the data show an approximately 50 percent reduction in calving within 2 km. following construction, the data also show an approximately two-fold increase in the total numbers within 6 km after the road was constructed.

It should also be noted that for the caribou to travel to the Milne Point area for calving, they have to cross at least the main Kuparuk road and pipeline, and some pass through the Kuparuk oilfield itself (Fig. 3).

There are two other points to keep in mind: first, there would be no gravel roads or pipelines constructed during the exploration phase, i.e., the first 10 or more years after leasing. Second, because road traffic is the main feature of an oilfield operation to which caribou respond (Curatolo and Murphy 1986), traffic control will be a particularly effective mitigation technique. It is certain that under an orderly approach, the U.S. Fish and Wildlife Service would impose restrictions on traffic and other activities when calving caribou are present.

There was no evidence that the local displacement in the Milne Point area had any negative effect on the caribou. The caribou continue to calve in the vicinity of oilfield development (Fig. 3), and the numbers that calved in the Milne Point study area approximately doubled after the road was constructed. There is no reason to believe that if displacement occurred around facilities in ANWR, there would be any detectable effect on calving caribou.

The Final LEIS is misleading in its discussion of the effects of the Prudhoe Bay oilfield on calving. There is no evidence that the Prudhoe Bay development area was ever a preferred calving area, although some calving did (and still does) occur there. For example, in late May 1971, Child (1971) found only 68 caribou (presumably most were pregnant females) in an approximately 50-mile stretch of coastal plain that included the Prudhoe Bay oilfield.

The Final LEIS (p. 121) correctly observes that predation is low in the range of the Central Arctic herd and that consequently survival has been high. However, it is incorrectly implied that the wolf population was reduced by "the influx of workers". First, oilfield workers and contractors are prohibited from possessing firearms. Second, nearly all tundra caribou populations throughout the Arctic are growing because of low rates of predation (Bergerud in prep.). These low rates of predation are a consequence of reduced predator populations (especially wolves) which have occurred for several reasons, including rabies outbreaks. Clearly, oilfield workers did not cause the reduction in wolf populations in the range of the Western Arctic Herd, Porcupine Herd, or in the central Canadian Arctic, any more than they did in the range of the Central Arctic herd.

CONCLUSION

If there should be an oilfield development within the ANWR Coastal Plain, caribou of the Porcupine Herd would continue to calve there as they do today. As with the caribou studied in the Milne Point area, calving animals would tend to occur in lower density within about 2 km. of the roads, pipelines, and other facilities. During the period when caribou are present, the U.S. Fish and Wildlife Service will impose restrictions to minimize activity in the oilfield and therefore minimize disturbance to the caribou. Caribou will not be displaced from their traditional calving grounds, and there is no reason to expect that the local response of caribou to oilfield facilities would have any significant effect on the population.

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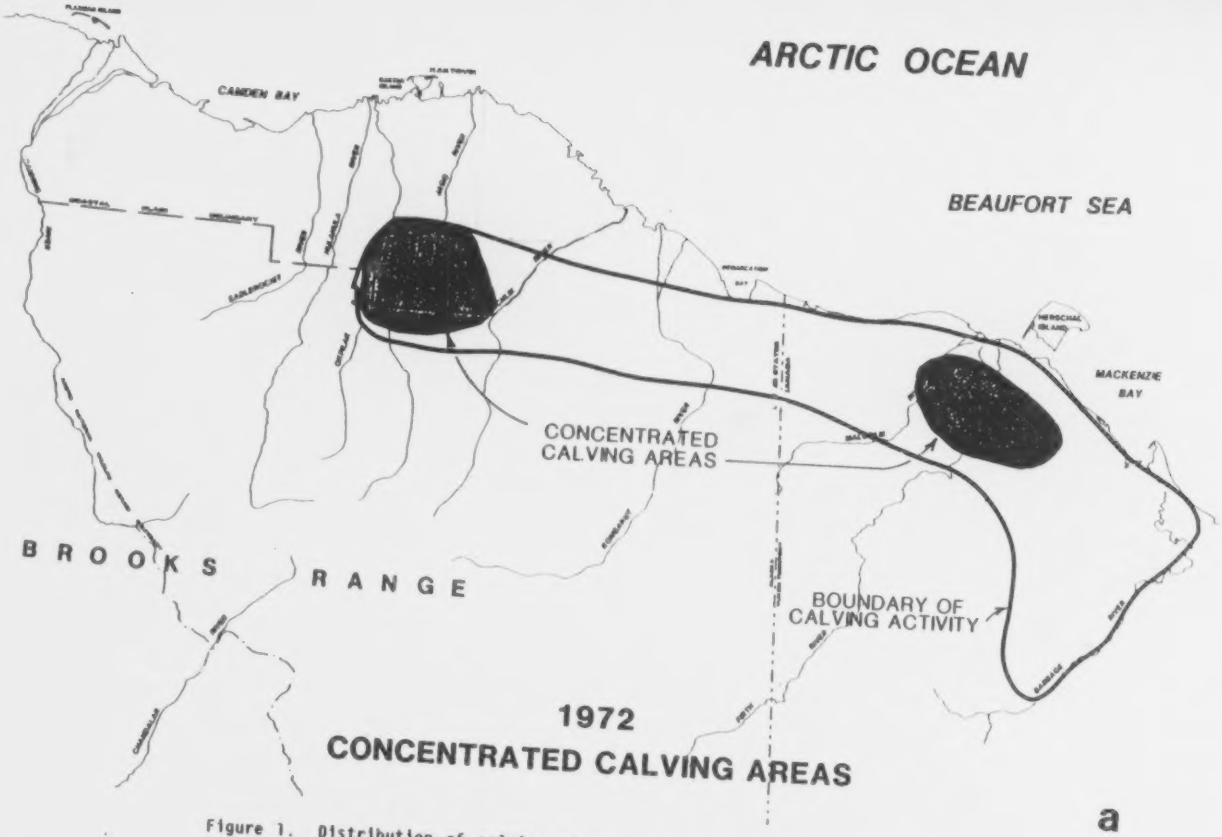

ARCTIC OCEAN
BEAUFORT SEA
CAMDEN BAY
HERSCHEL ISLAND
MACKENZIE BAY
BROOKS RANGE
CONCENTRATED CALVING AREAS
BOUNDARY OF CALVING ACTIVITY
1972
CONCENTRATED CALVING AREAS
a

Figure 1. Distribution of calving of the Porcupine caribou herd in selected years. a. 1972, calving was distributed approximately equally between Alaska and the Yukon. b. 1981, the majority of calving took place in Alaska. c. 1982, the majority of calving took place in the Yukon.

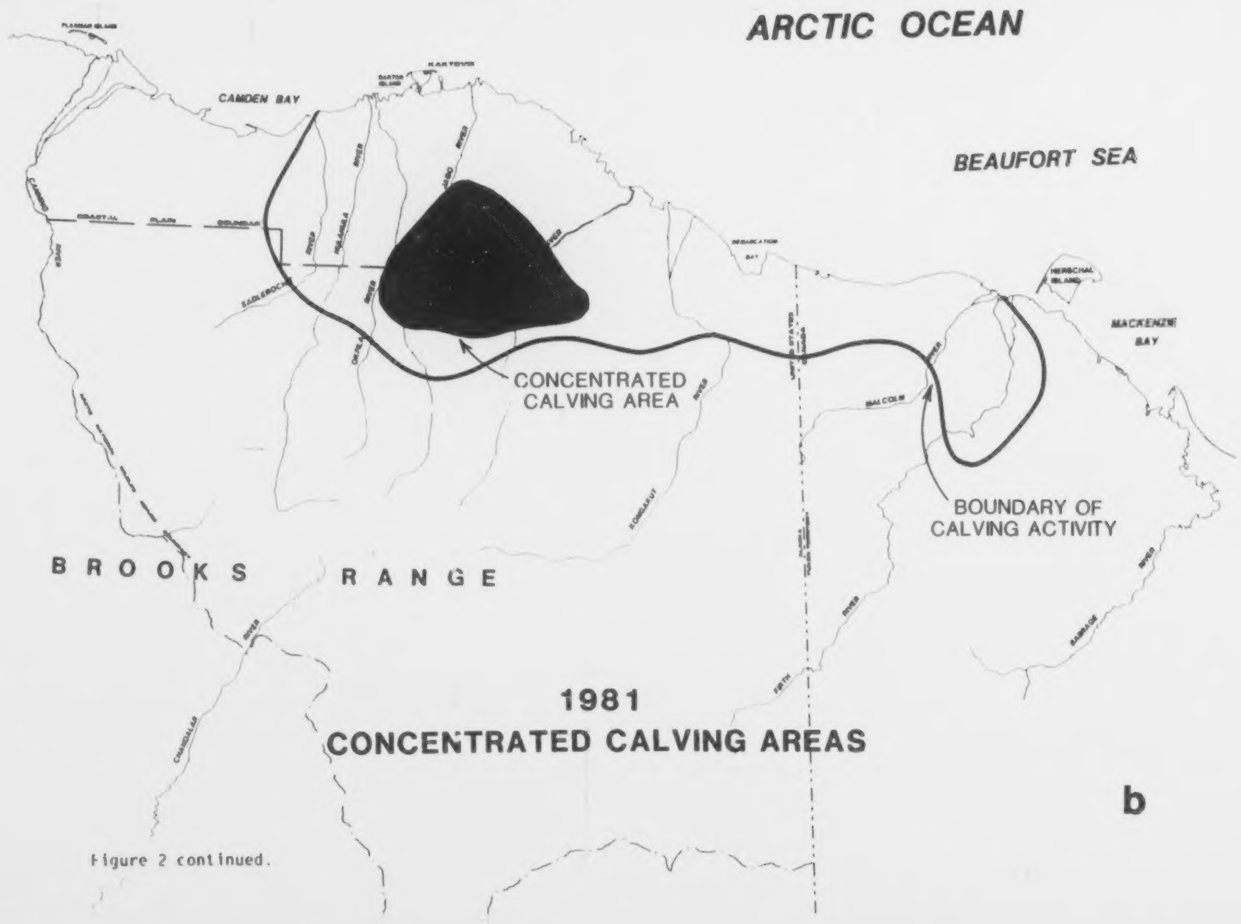


Figure 2 continued.

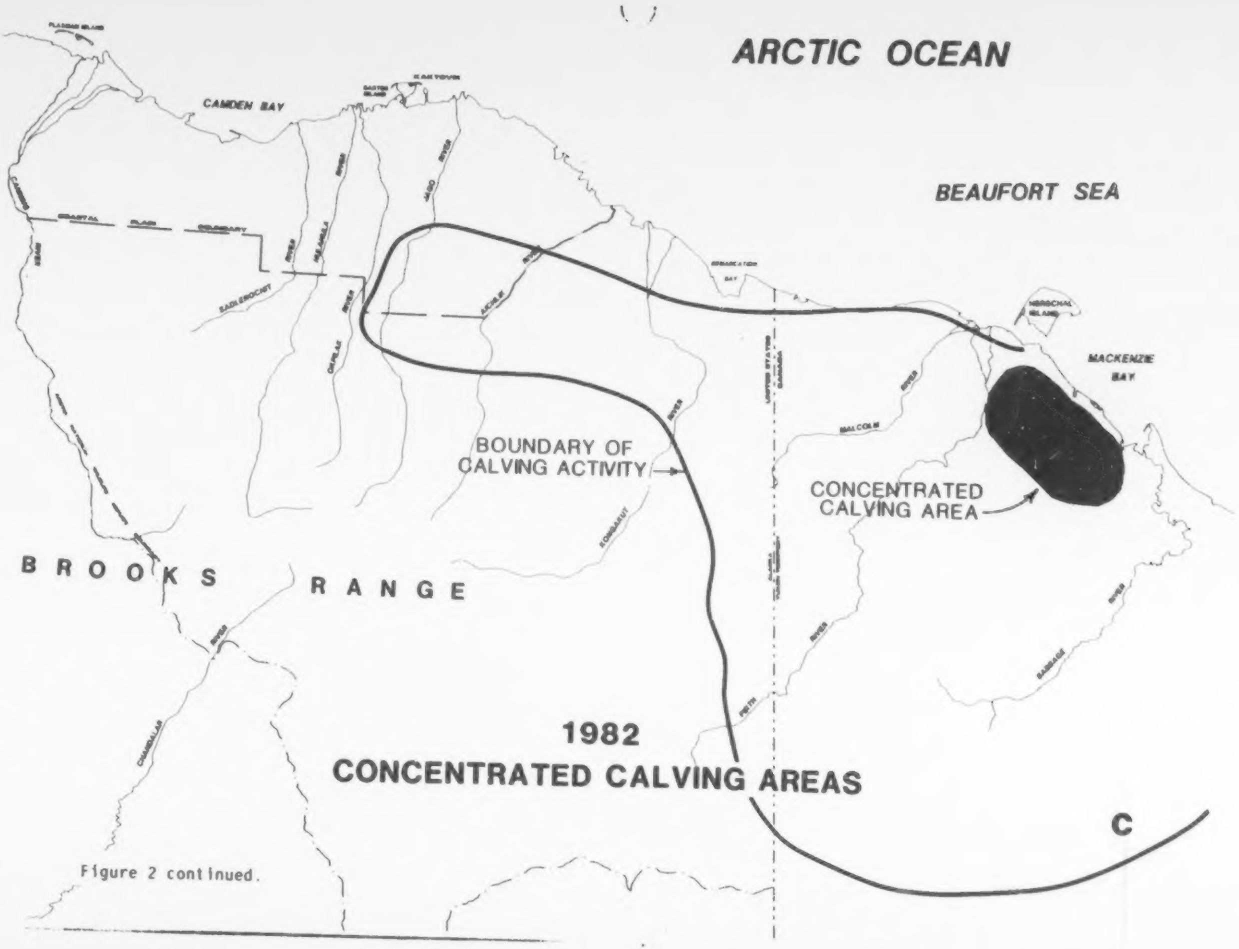
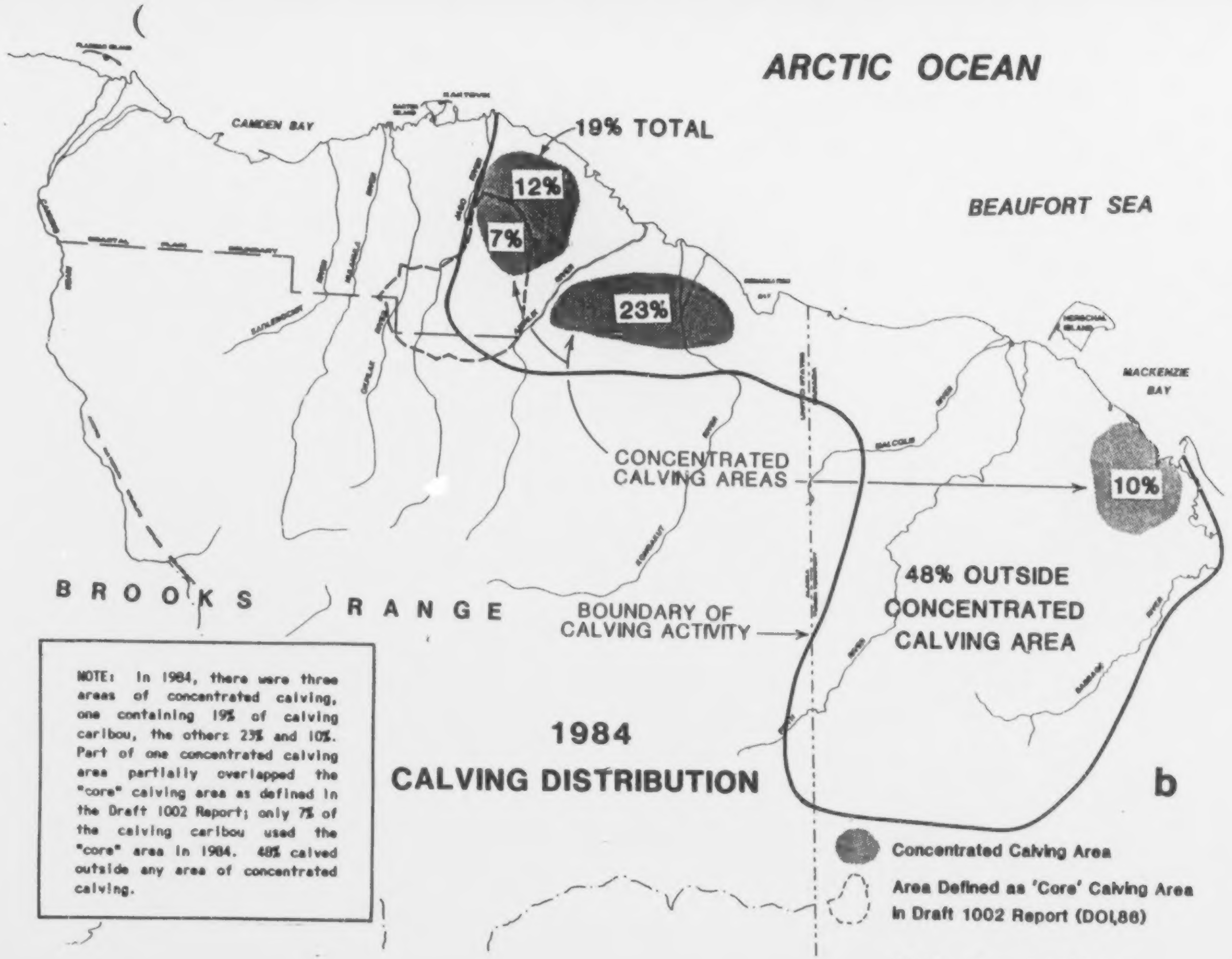


Figure 2 continued.


ARCTIC OCEAN
BEAUFORT SEA
CAMDEN BAY
MACKENZIE BAY
19% TOTAL
12%
7%
23%
10%
CONCENTRATED CALVING AREAS
BOUNDARY OF CALVING ACTIVITY
48% OUTSIDE CONCENTRATED CALVING AREA
BROOKS RANGE
b
Concentrated Calving Area
Area Defined as 'Core' Calving Area in Draft 1002 Report (DOI,88)

1984
CALVING DISTRIBUTION

NOTE: In 1984, there were three areas of concentrated calving, one containing 19% of calving caribou, the others 23% and 10%. Part of one concentrated calving area partially overlapped the "core" calving area as defined in the Draft 1002 Report; only 7% of the calving caribou used the "core" area in 1984. 48% calved outside any area of concentrated calving.

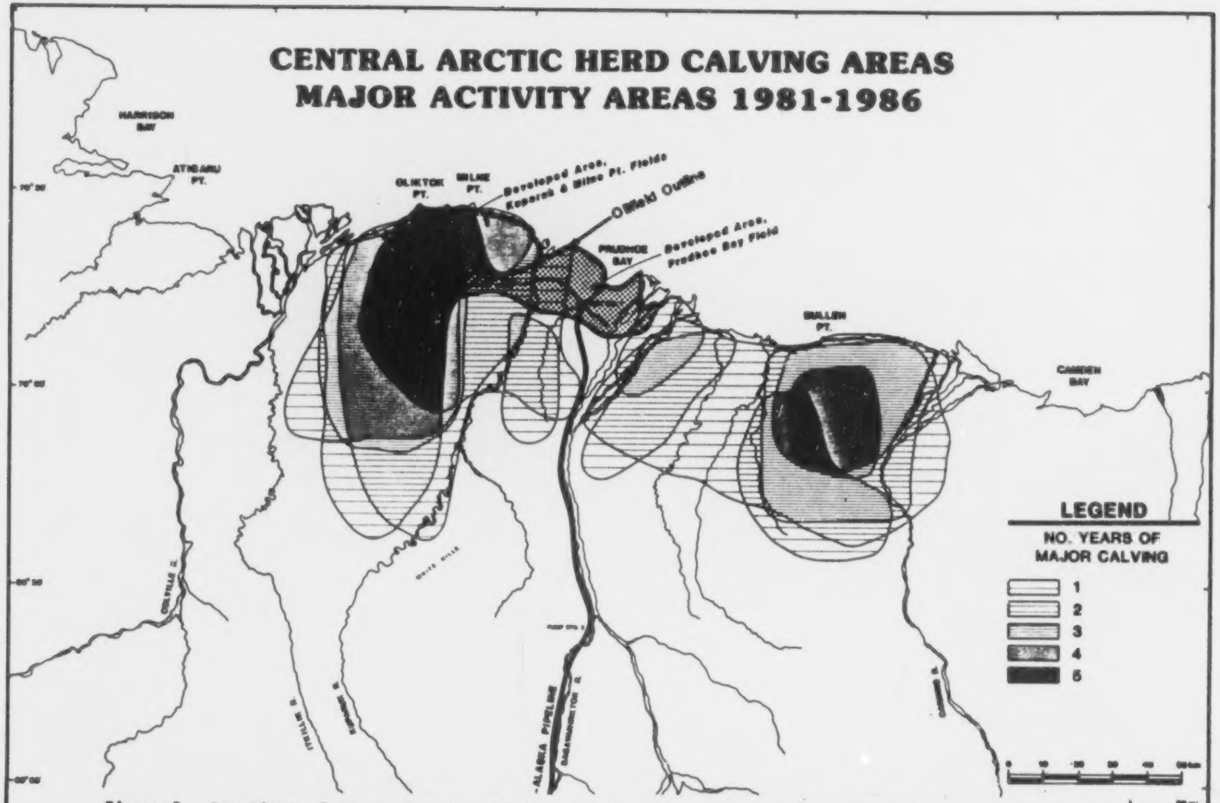


Figure 3. Locations of areas of major calving activity of the Central Arctic Herd, 1981-1986. Note the presence of calving caribou within the general area of the Prudhoe Bay, Kuparuk, and Milne Point oilfields. The Prudhoe Bay Oilfield has never been known to be used often by calving caribou, even prior to development. [Based on data provided by RRCS (1985) and Jakimchuk 1986, pers. comm.].

CARIBOU HERDS:

	Location	Source	Name	Size	(year)
1.	Alaska	1	Adak	300	(1985)
2.	Alaska	1	Alaska Peninsula (North)	20,000	(1985)
3.	Alaska	1	Peninsula (South)	6,000	(1986)
4.	Alaska	1	Western Arctic	233,000	(1986)*
5.	Alaska	1	Beaver Mountains	1,600	(1985)
6.	Alaska	1	Chisana	1,100	(1981)
7.	Alaska	1	Delta	7,700	(1986)
8.	Alaska	1	Forytmile	15,500	(1986)
9.	Alaska	1	Kenai (lowland)	85	(1985)
10.	Alaska	1	Kenai (mountain)	400	(1985)
11.	Alaska	1	McKinley	2,500	(1986)
12.	Alaska	1	Mentasta	3,000	(1986)
13.	Alaska	1	Mulchatna	42,900	(1985)
14.	Alaska	1	Nelchina	27,528	(1985)
15.	Alaska	2	Porcupine	181,000	(1986)
16.	Alaska	3	Central Arctic	16,000	(1986)
17.	Alaska	1	Teshekpuk Lake	10,800	(1984)
18.	Alaska	1	Andreafsky	1,200	(1985)
19.	Alaska	1	Big River (McGrath)	750	(1984)
20.	Alaska	1	Kilbuck Mountains	75	(1985)
21.	Alaska	1	Kuskokwim Mountains	600	(1983)
22.	Alaska	1	Macomb Plat.	700	(1985)
23.	Alaska	1	Rainy Pass	1,500	(1982)
24.	Alaska	1	Ray Mountains	2,000	(1986)
25.	Alaska	1	Sunshine Mountain	600	(1985)
26.	Alaska	1	Tonzona	<-1,000	(1983)
27.	Alaska	1	White Mountains	800	(1983)
28.	Alaska	1	Yanert	700	(1986)
			ALASKA TOTAL:	579,340	

Canada (Large Herds Only)

	Location	Source	Name	Size	(year)
29.	Canada	4	George River	600,000	(1983-85)*
30.	Canada	4	Bathurst	385,000	(1983-85)*
31.	Canada	4	Beverly	335,000	(1983-85)*
32.	Canada	4	Bluenose	65,000	(1983-85)
33.	Canada	4	Kaminuriak	230,000	(1983-85)*
			CANADA TOTAL:	1,615,000	
			NORTH AMERICA TOTAL:	2,194,340	

Sources:

1. Alaska Department of Fish and Game, population and harvest estimates.
2. Final Legislative EIS (DOI 1987).
3. 1985 Industry Government Caribou Workshop.
4. A. T. Bergerud. 1986. Caribou, Wolves, and Man, (unpublished, MS).

*Herds as large as or larger than the Porcupine Herd.

WILDLIFE

CARIBOU

- Despite the dire predictions of 15 years ago, Prudhoe Bay and TAPS have not adversely affected the caribou population.
- Since development began in the early 1970's, the Central Arctic Herd has increased from 3,000 animals to more than 15,000 in 1986.
- Traditional calving area for the Central Arctic Herd remains unchanged and includes areas of the Kuparuk and Milne Point oilfields.
- All caribou populations in the Northern Hemisphere have been growing rapidly, apparently because of low predator populations in general.
- The following four caribou herds are found on the Alaskan North Slope:

  Porcupine Herd, 180,000 (ANWR/Canada)
  Central Arctic Herd, 15,000+ (Prudhoe/Kuparuk)
  Teshekpuk Herd, 5,000+ (NPRA)
  Western Arctic Herd, 250,000 (NPRA)

- There are 28 caribou herds in Alaska totaling approximately 579,340 caribou.
- The five largest herds in Canada total approximately 1,615,000 animals.
- The total number of caribou in North America is approximately 2,200,000.

BIRDS

- Species diversity and nesting densities have remained virtually unchanged within the Prudhoe Bay development area.
- A recent bird study at Prudhoe Bay showed that waterfowl preferred areas adjacent to roads, apparently because of earlier snowmelt in those areas.
- Most bird species are on the North Slope only 2-3 months of the year.

BIRD SPECIES

- In the summer there are 230 species of birds present (100 actually breed on coastal plain).
- In the winter the following bird species are found: Raven, Ptarmigan, Snowy owl, and Gyrfalcon.
- The following are the most common bird species: Lapland Longspur, Semipalmated Sandpiper, Red-necked Phalarope, Dunlin, Red Phalarope, Stilt Sandpiper, Oldsquaw, Greater White-fronted Geese, and King Eider.

OTHER MAMMALS

- Grizzly bears, polar bears, wolves, and red fox are rare at Prudhoe Bay.
- Arctic fox, voles, and lemmings are common at Prudhoe Bay.

DEVELOPMENT ZONES OF INFLUENCE

June, 1987

A White Paper Prepared By
THE STANDARD OIL COMPANY

7436U

DEVELOPMENT ZONES OF INFLUENCE

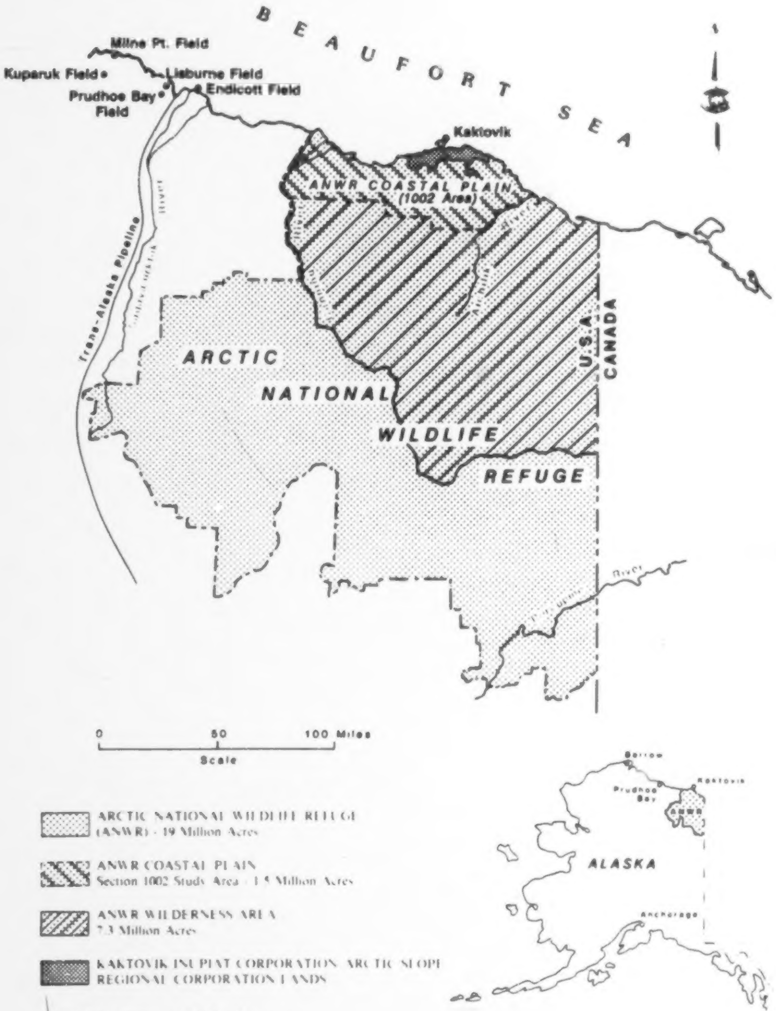
Introduction

The term zone of influence is sometimes used in discussing ways in which petroleum development in the "1002 area" of the Arctic National Wildlife Refuge (ANWR) (Fig. 1) might adversely affect fish and wildlife. Three distinct mechanisms have been identified by which zones of influence could -- hypothetically -- be produced: direct habitat removal and modification, displacement of wildlife from habitat, and blockage of wildlife from habitat.

A zone of influence is an area inside which habitat characteristics or availability are altered due to the presence of an introduced structure or human activity. If petroleum exploration, development, and production proceed in the 1002 area, introduced structures will include gravel roads and drill pads, pipelines, and support buildings. Human activities will include vehicle and aircraft traffic, gravel mining, construction of facilities, drilling of exploration and production wells, and other functions necessary for oilfield development and operation.

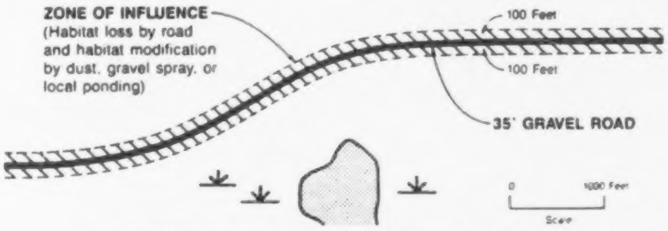
The Final ANWR Coastal Plain Resource Assessment and Legislative Environmental Impact Statement prepared by the Department of the Interior (DOI) in April 1987 describes three distinct zones of influence that can be caused by development. According to the report, each zone is formed by one of three mechanisms acting on habitat or directly on wildlife. Listed by increasing size of the zone produced (Fig. 2), these mechanisms are:

1. Direct habitat loss and modification (site-specific),
2. Displacement of wildlife from habitat (immediate vicinity), and
3. Blockage of access to habitat (regional).

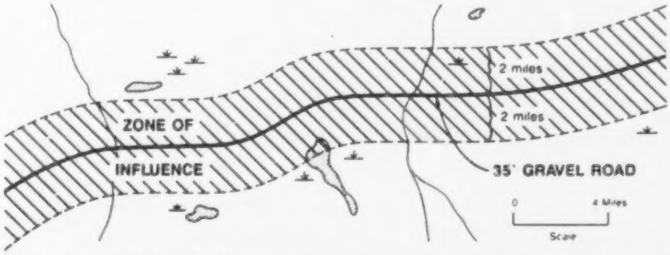

BEAUFORT SEA
Milne Pt. Field
Kuparuk Field
Lisburne Field
Prudhoe Bay Field
Endicott Field
Kaktovik
ANWR COASTAL PLAIN (1002 Area)
Trans-Alaska Pipeline
ARCTIC NATIONAL WILDLIFE REFUGE
U.S.A.
CANADA
River
0
50
100 Miles
Scale
ARCTIC NATIONAL WILDLIFE REFUGE (ANWR) - 19 Million Acres
ANWR COASTAL PLAIN Section 1002 Study Area - 1.5 Million Acres
ANWR WILDERNESS AREA 7.3 Million Acres
KAKTOVIK INUPIAT CORPORATION ARCTIC SLOPE REGIONAL CORPORATION LANDS
Barrow
Kaktovik
Prudhoe Bay
ANWR
ALASKA
Anchorage

Modified from: ASRC 1986

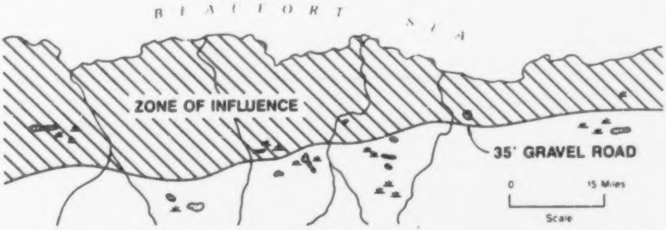
FIGURE 1. ARCTIC NATIONAL WILDLIFE REFUGE


ZONE OF INFLUENCE
(Habitat loss by road and habitat modification by dust, gravel spray, or local ponding)
100 Feet
100 Feet
35' GRAVEL ROAD
0
1000 Feet
Scale

2A. SITE-SPECIFIC: Habitat Loss or Modification
(Zone of influence is 235 ft. wide: 35-ft. road plus 100 ft. on each side)



2B. IMMEDIATE VICINITY: Hypothetical Displacement of Wildlife from Habitat
(Zone of influence is approximately 2 miles on each side of road)



2C. REGIONAL: Hypothetical Blockage of Wildlife from Habitat
(Zone of influence includes all land on one side of road)

FIGURE 2. HYPOTHETICAL ZONES OF INFLUENCE (ACCORDING TO DOI 1987)

Because direct loss or modification of habitat would be site-specific and limited in extent, this mechanism is considered unlikely to produce detectable adverse effects on fish and wildlife of the 1002 area. Large zones of influence based on displacement and blockage are unsupported by published evidence, which substantiates only local, transient changes in habitat use. If such zones really existed, the Prudhoe Bay, Kuparuk, Lisburne, Endicott, and Milne Point oilfields on the Alaskan North Slope would be biological wastelands in terms of wildlife use. This clearly is not the case.

The following sections examine the probable biological importance of postulated zones of influence. The analysis is based on the full leasing scenario (Alternative A) described in the DOI report, which assumes sequential development of three large oilfields inside the 1002 area (DOI 1987). The actual pattern of development and number of fields would be determined by results of petroleum exploration conducted after leasing and would depend on the discovery of economically viable reserves.

Direct Habitat Loss and Modification

Direct loss and local modification of habitat (Fig. 2A) would produce a small but unavoidable zone of influence around oilfield facilities -- about 0.8 percent of the 1002 area. Although oilfield layout and facility siting are designed to consolidate structures and produce the smallest feasible "footprint", some direct covering of habitat by oilfield facilities is inevitable. In addition, gravel spray and airborne dust are generated by construction activities and vehicle traffic, and local ponding may occur where surface water accumulates along roads. These secondary effects would form a margin of modified habitat about 100 feet wide around oilfield facilities. This narrow band would continue to be used by wildlife.

Gravel Pads. Oilfield development and operation in the Arctic require laying down gravel insulation (usually called a "pad") so that the underlying permafrost will remain frozen and support roads, drill sites, and other structures. Gravel pads are generally about 5 feet thick and obviously create a local zone of influence inside which all habitat is covered. The DOI report states that full leasing and development of three large fields within the 1002 area "would eventually result in approximately 5,000 acres of vegetation being covered by gravel for roads, pipelines, airstrips, and other facilities" (DOI 1987).

If obtaining gravel for pads requires removal of covering vegetation, additional direct loss of habitat occurs. Mining gravel for this purpose in the 1002 area could remove about 650 acres of tundra vegetation, according to DOI. Therefore, approximately 5,650 acres of tundra would be covered or removed for oilfield development under Alternative A, full leasing of the 1002 area (DOI 1987). By comparison, the total area directly covered by gravel roads and pads is 6,920 acres for all North Slope oilfields (Prudhoe Bay, Kuparuk, Milne Point, Endicott, and Lisburne). An additional 1,260 acres of vegetation has been removed for gravel sites and landfills associated with these five fields, producing a total of 8,180 acres directly affected (Heiken 1987). As oilfield design and technology have steadily improved, consistently less habitat has been removed or covered during each successive development. This trend would continue in 1002 oilfield design and development, which would be conducted under close agency supervision through federal, state, and North Slope Borough regulatory review, permit stipulations, and field monitoring.

Secondary Effects. The DOI report points out that in addition to the direct habitat removal described above, secondary effects would result from gravel spray and dust deposition in areas adjacent to roads (Fig. 2A). These effects would be produced during road construction and subsequently by vehicle traffic, although frequent road watering would greatly minimize traffic-generated dust. In addition, some local ponding of water would occur along roads and drill pads, and there would be earlier-than-usual spring snowmelt along heavily traveled roads where dust on the surface of the snow would increase absorption of solar radiation. The DOI report assumes that secondary effects would extend 100 feet on each side of all roads, drill pads, and other facilities. Based on estimates of facilities required for three large fields, DOI concludes that "approximately 7,000 acres of existing vegetation [tundra] could be modified by these secondary effects" (DOI 1987).

Use of Modified Habitat. It should be kept in mind that North Slope habitat locally modified by dusting, ponding, and other secondary effects remains available to wildlife. A substantial body of information, including data from recent studies, demonstrates that very little change has occurred in local or regional levels of habitat use associated with North Slope oilfields. For example, Troy (1987) conducted a major study at Prudhoe Bay during the 1986 breeding season to investigate effects on bird distribution and abundance attributable to the 10-year presence of the Prudhoe Bay oilfield. For the most abundant bird species, that study found no difference in species composition between developed and undeveloped portions of the oilfield and, with one exception, no statistically significant difference in nest densities between developed and undeveloped areas. (Semipalmated sandpiper nests were less abundant in developed parts of the field. However, there is no apparent population effect, and these sandpipers remain the second most abundant species in the area.) Thus, while development of the 1002 area would produce local habitat modifications along roads and pads, evidence indicates that such modifications would have little influence on wildlife occurrence.

The estimated 7,000-acre area of secondary modification, when added to the approximately 5,650 acres that would be directly covered by gravel or removed for gravel mining, would produce a composite zone of influence involving about 12,650 acres of coastal plain tundra, or 0.8 percent of the 1002 area (Fig. 3). As the DOI report states, removal or modification of only 0.8 percent of the 1002 area's acreage would not alter the ability of the area to support present or future fish and wildlife populations: a conclusion demonstrated by actual experience from existing North Slope oilfields.

Displacement of Wildlife from Habitat

A second, indirect means by which zones of influence are predicted to act on wildlife is through displacement. In theory, a reduction in habitat

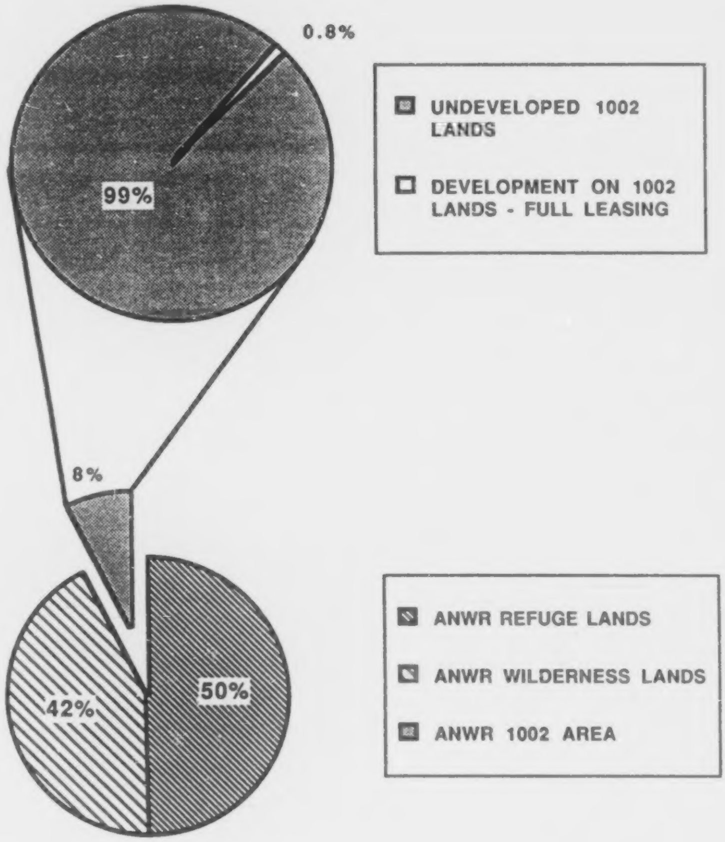


FIGURE 3. ANWR LAND USE

value would result in developed areas from consistent, long-term avoidance by wildlife. Habitat value would be reduced in the sense that the habitat, although unchanged, would no longer be fully used. Such avoidance would supposedly produce a zone of vacant or sparsely occupied habitat surrounding oilfield structures outward to a distance of several miles, depending on the species (Fig. 2B). The DOI report uses the term "spheres of influence" to describe these hypothetical areas of diminished habitat use.

A major problem with the displacement hypothesis is that avoidance by wildlife is not observed around existing North Slope oilfield facilities, except in narrow zones along roads and in direct, short-term response to nearby human activity. Even in these instances, avoidance is only partial and tends to be highly variable. For example, there is no evidence of large-scale displacement of caribou. One study reported a statistical trend in which caribou cows with calves were present in reduced densities within about 1.2 miles of an oilfield road (Dau and Cameron 1986). Beyond that distance, densities were indistinguishable from those in roadless areas. Other investigators found that caribou moving through an oilfield production area reacted variably to nearby structures and tended to steer clear of drilling sites, but changes in habitat use patterns were not observed (Wright and Fancy 1980; Fancy et al. 1981; Fancy 1982, 1983). None of these findings indicated that large areas of habitat were abandoned by or made inaccessible to caribou as a result of oilfield development. Although the Dau and Cameron (1986) study suggested that calving densities may be lower immediately adjacent to oilfield structures, there is no question that the Central Arctic herd continues to calve in its traditional calving area, which includes the Kuparuk oilfield. The herd increased in size from about 3,000 at the time that North Slope oilfield development began in the early 1970s to about 15,000 in 1985 (RRCS 1985; Shideler 1986).

The displacement argument is apparently based on the assumption that wildlife populations in the Arctic are at or near the carrying capacity of their habitat, and that local avoidance of oilfield structures would prevent wildlife from using areas necessary to maintain existing numbers of animals. This assumption is not supported by scientific evidence. Availability of Arctic Coastal Plain habitat has not been shown or convincingly suggested to be a factor limiting most wildlife populations using the coastal plain. For example, caribou and muskox populations are maintained well below carrying capacity by predation, hunting, and severe winter conditions (Bergerud 1971; Walters et al. 1975, 1978; White et al. 1975; Gunn 1984; Bergerud et al. 1984). Similarly, factors such as predation, the short arctic summer, severe winter conditions, and shortage of overwintering habitats outside the Arctic appear to limit the population size of many bird species using the Arctic Coastal Plain (King 1970; McKnight and Hilliker 1970; Ogilvie 1978; Myers et al. 1987). Thus, for most wildlife of the 1002 area, local changes in habitat use resulting from behavioral avoidance of oilfield structures or activities would have little bearing on population size.

Although the Central Arctic herd continues to increase in number, concern has been expressed that caribou of the Porcupine herd would decline as a result of 1002 area development. It is contended that because the coastal plain in the 1002 area is narrower than at Prudhoe Bay, the larger Porcupine herd has less area available for calving and is "crowded" (DOI 1987). Therefore, displacement during calving would lead to even greater crowding, with adverse consequences. There are two things wrong with this argument: first, the Porcupine herd is not crowded on its calving grounds, and second, there is no known reason why greater calving density should necessarily be detrimental. The range of densities reported for local areas of very high calving concentrations is 25 to 69 cows per square mile (calculated from DOI 1987). The density of cows averaged over the entire calving range would be far lower, and well within the range of average densities cited for other herds. For example, average calving densities cited for the Kaminuriak herd in central Canada were reported to range from about 1 to 48 cows per square mile (Parker 1972). There is clearly no basis for asserting that the Porcupine herd is "crowded" on its calving grounds.

Furthermore, it is implied that displacement during calving would harm the Porcupine herd in some unspecified way. However, no basis for this prediction has been provided. DOI (1987) correctly states that the important thing is for calves to be born in an area where they can avoid predation. There is no reason why predation would be more likely if oilfield infrastructure were present on the calving grounds. Even if some animals were completely displaced from within a 2-mile zone of influence, as assumed by DOI (1987), they would still be located on their traditional calving grounds and would face no increased threat of predation from this minor change in position. The caribou displacement issue evaporates when it is analyzed biologically, because there is no known mechanism linking displacement with reduced calf survival.

Zones of influence based on displacement have been postulated for other species in the 1002 area. For example, displacement is the primary basis for predictions of adverse effects on muskoxen (DOI 1986). Two reports are cited for support, Russell (1977) and Reynolds and LaPlant (1985). However, Russell (1977) observed only temporary reactions to winter seismic surveys and concluded that population-level effects on muskoxen were unlikely. He also noted that muskoxen show a tendency to habituate to continued human presence. Reynolds and LaPlant (1985) concluded that "Muskoxen apparently were not displaced from areas of traditional use in 1984. All muskoxen observed were within or near use areas documented in 1982-1984." These authors also reported that movements of muskoxen away from seismic survey activities were "apparently of relatively short duration and herd or population size did not appear to be affected."

Thus, examination of papers cited as support for the displacement hypothesis indicates that regional, long-term displacement has not been observed. Urquhart (1973), Beak Consultants Ltd. (1976), Jingfors and Lassen (1984), and Reynolds and LaPlant (1985) all reported that muskoxen sometimes made local, short-term movements away from seismic exploration activities. As with caribou, the treatment of muskoxen illustrates the difficulty of using displacement from hypothetical zones of influence to predict adverse effects of petroleum development on wildlife.

Blockage of Access to Habitat

In theory, blockage of animal movement could "remove" or "reduce the value" of very large areas of habitat, in the sense that the habitat would be inaccessible and therefore no longer used by wildlife. This argument has been used to postulate a third, much more extensive category of zone of influence based on roads and pipelines acting as barriers to wildlife.

Roads and Pipelines as Barriers. If a road or pipeline were built across a stretch of tundra, a vast expanse of untouched land on one side of the corridor could be said to lose "habitat value" because of the potential of the structure to block wildlife attempting to cross from the other side (Fig. 2C). The potential blockage is typically expressed in terms of the amount of habitat on the other side of a road or pipeline -- the number of acres in the "zone of influence" -- rather than in terms of the number of animals or percentage of the population that might be deterred from crossing. This is the case for caribou assessments presented in the DOI report, which implies that 294,000 acres lie within a zone of influence north of the hypothetical pipeline/road corridor analyzed for Alternative A. The report states that "If caribou are inhibited by road/pipeline development, then use of 52 percent of estimated insect-relief habitats (including as much as 80 percent of the coastal habitat) could be reduced" (DOI 1987).

Evidence of Crossing Success. A biologically more appropriate assessment is to base predictions on observed rates of crossing success reported in the scientific literature. There is abundant published evidence that some caribou in a group are sometimes slowed or temporarily deflected from crossing a pipeline, road, or drill site perimeter, while the majority crosses without delay (e.g., Banfield 1954; Davis et al. 1977; Roseneau 1979; Cameron and Whitten 1980; Fancy 1982, 1983; Fancy et al. 1981; Curatolo et al. 1982; Robus 1983; Bergerud et al. 1984; Russell and Martell 1985). A study of the Porcupine caribou herd in its winter range in Canada's Yukon Territory found that the presence of the Dempster Highway had no "consistent, detectable effect" on caribou movements (Russell and Martell 1985). Bergerud et al. (1984) stated that observed temporary deflections by caribou, resulting in movement parallel to linear man-made structures, are similar to deflections observed in response to natural terrain features such as snow-filled valleys, eskers, and steep mountain ranges. The deflections appear to follow the "path of least energetic resistance" and are observed at least as frequently in nature as in the vicinity of oilfields. While temporary route diversions may occur, the overall direction of movement is unchanged.

Zones of influence caused by man-made barriers have been said to affect other species. For example, oilfield roads have been predicted to block movements of geese during brood-rearing and molting (when they are flightless). It was widely predicted that a road planned for the North Slope's Endicott Development Project would prevent brood-rearing groups of adult and young snow geese from reaching feeding habitats after leaving their nesting colony. Therefore, movements of brood-rearing groups were closely monitored during construction of the road. Within one week after hatching, 42 percent of adults and 28 percent of goslings crossed the Endicott Road. Traffic levels averaged over 60 vehicles per hour, computed over 24 hours. Nevertheless, snow geese used habitats within 125 meters of the road, and no direct mortality associated with the road was documented (Burgess and Ritchie 1987). In another study, geese and swans in the Lisburne Development Area routinely crossed under pipelines (Hampton and Joyce 1985).

If oilfield structures really did act as barriers, existing roads, pipelines, and other facilities at Prudhoe Bay, Kuparuk, and elsewhere on the North Slope would stop caribou, other mammals, and flightless birds from reaching and using large areas of habitat. Scientific studies would have reported major disruptions in distribution, regional habitat use, and even population size. None of this has happened. Evidence shows that existing structures do not act as barriers and do not prevent wildlife from freely entering and using habitat. Zones of influence postulated on such effects are hypothetical and unsubstantiated.

Routine Mitigation Measures. Mitigating features are routinely and effectively built into oilfield design and layout to ensure that roads and pipelines do not act as barriers to free passage by wildlife. It is now over 10 years since Prudhoe Bay oilfield development began, and many innovative environmental protection measures have been devised since then. They include elevating pipelines or providing crossing ramps, separating pipelines from roads to reduce visual and physical barriers, and consolidating buildings wherever feasible to reduce the cumulative area of tundra covered by gravel pads. More recent mitigation includes reduced wellhead spacing, which greatly consolidates the total land area covered by individual wellheads; horizontal drilling, which allows drilling of numerous wells from a single site; and annular injection, which entails disposal of drilling lubricants by injecting them deep beneath the earth's surface instead of containing them at the surface. These measures limit habitat removal or alteration and minimize the total number of structures actually built within a development area.

Mitigation features like these are often overlooked because they are quietly and routinely incorporated into exploration planning and oilfield design by the engineers themselves. Yet this approach is entirely consistent with the intent of the National Environmental Policy Act of 1969, implementing regulations of the President's Council on Environmental Quality, and with mitigation policies of the U.S. Fish and Wildlife Service (FWS 1981) and the Alaska Department of Fish and Game. These measures place highest priority on avoiding adverse impacts in the first place, and secondly on minimizing impacts that cannot be entirely avoided.

Summary and Conclusions

The risk is very small that full leasing and development of the 1002 area for petroleum production would produce any measurable change in the population characteristics of any fish or wildlife species present at any time of the year, or that the future ability of habitat to support fish and wildlife populations would be measurably reduced.

Adverse effects based on "zones of influence" cannot be predicted unless a mechanism is demonstrated to link such a zone with a factor regulating wildlife population characteristics. Furthermore, of the three mechanisms that might create such zones, only site-specific habitat loss and modification would actually occur. The other two processes, large-scale displacement and blockage of wildlife, have not been documented for any North Slope oilfield and are purely hypothetical. Conclusions regarding these mechanisms are summarized below.

Direct Habitat Loss and Modification. Approximately 12,650 acres of habitat would be directly covered or modified by development of three large oilfields within the 1002 area of ANWR. The resulting zone of influence would include roads, drill pads, and other oilfield facilities and 100-foot borders of modified habitat.

- Direct habitat loss or modification would involve only about 0.8 percent of the 1002 area and would temporarily affect the ability of these 12,650 acres to support fish and wildlife populations. Therefore, this mechanism cannot serve as a basis for predicting adverse biological consequences of oil and gas development in the 1002 area (DOI 1987).
- Predictions of biologically significant adverse effects are based on much larger zones of influence involving hypothetical displacement or blockage of wildlife.
- However, only the first type of effect, direct habitat loss and modification, would occur with any certainty. Predictions of major or even moderate effects based on wildlife displacement or blockage are not supported by evidence.

Displacement of Wildlife From Habitat. Predictions of widespread habitat abandonment and population declines have been made on the assumption that wildlife would be displaced from zones of influence created by petroleum development in the 1002 area.

- Regional zones of influence based on wildlife displacement are hypothetical and are not supported by evidence. Therefore, displacement is not a sound basis for predicting adverse biological consequences of oil and gas development in the 1002 area.
- Observed behavioral reactions of caribou and muskoxen to oilfield structures and petroleum exploration activities have been local, not regional, and have usually involved short-term avoidance responses.

- Even if long-term displacement did occur as a result of petroleum development in the 1002 area, evidence indicates that sufficient habitat would still be available to support maximum population sizes likely to be reached by most arctic wildlife species.

Blockage of Access to Habitat. Predictions of large areas from which wildlife would be excluded by oilfield structures are not substantiated by evidence. No study has indicated that wildlife are blocked by North Slope roads and pipelines, and regional zones of vacant or sparsely occupied habitat have not been observed near oilfields.

- As shown by numerous studies, caribou movements have been generally unaffected by roads, pipelines, drilling sites, and other North Slope oilfield structures. Temporary deflections in response to structures have been observed. However, there has been no discernable effect on regional distribution, migration patterns, calving success, herd size, productivity, or other biologically important characteristics. Similar conclusions have been reached with regard to brood-rearing and molting waterfowl.

- Free passage of wildlife is assured by mitigation features which are routinely built into oilfield design and layout and which are proven to be effective.

- Predictions of adverse effects based on blockage of free passage by roads, pipelines, and other structures would have validity only if the blockage did in fact occur. Because there is no evidence of such blockage affecting caribou, muskox, polar bear, snow goose, arctic char, or any other North Slope species, this category of zone of influence has no basis in fact. On the other hand, abundant evidence from government, industry, and academic studies demonstrates that North Slope oilfield development has not affected the regional distribution, habitat use, or population characteristics of any species.

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ANWR COASTAL WILDERNESS

- o Approximately 450,000 acres of the Arctic National Wildlife Refuge (ANWR) coastal plain is legally designated wilderness.

- o The coastal wilderness includes a 30-plus mile stretch of coastline.

- o The coastal wilderness area joins the 3 million acre Northern Yukon National Park extending the coastal area that will be completely unaffected by oil and gas activity in the 1002 area.

- o The ANWR coastal wilderness area includes a complete continuum of terrain and habitat types

- o River systems in the coastal wilderness portion of ANWR include:

  Aichilik River
  Egaksrak River
  Kongakut River
  Clarence River

- o 8 million acres, 42% of ANWR, has been legally designated wilderness.

- o The 1002 area, 1.5 million acres, is only 8% of ANWR.

- o 3 oilfields within the 1002 area would alter less than 1% of the habitat.

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ANWR COASTAL PLAIN WILDERNESS:
THE 1002 AREA IN PERSPECTIVE

May, 1987

A White Paper Prepared By
THE STANDARD OIL COMPANY

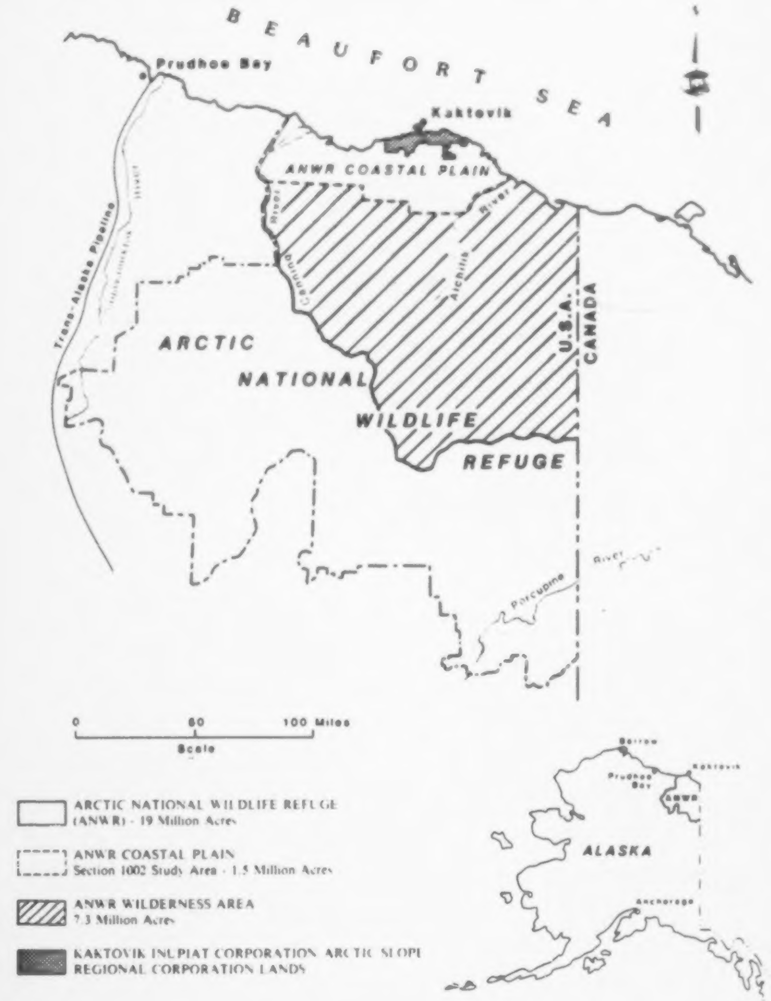
ANWR COASTAL PLAIN WILDERNESS:
THE 1002 AREA IN PERSPECTIVE

Three Misconceptions

A common misconception about the Arctic National Wildlife Refuge (ANWR) is that oil and gas leasing in one particular area of the coastal plain, the "1002 area" (Fig. 1), would lead to development of the entire ANWR coastal plain and loss of its wilderness qualities. The area singled out by Section 1002 of the Alaska National Interest Lands Conservation Act of 1980 (ANILCA) does not include all of the ANWR coastal plain. Congress chose to protect a significant portion of the coastal plain by incorporating it into the National Wilderness System, while retaining the 1002 parcel for evaluation of its petroleum potential and fish, wildlife, and habitat values. It is sometimes forgotten that an extensive range of coastal plain wilderness, including approximately 450,000 acres with a 30-mile stretch of coastline, lies east of the 1002 area between the U.S.-Canada border and the Aichilik River, which marks the eastern boundary of the 1002 area. This forgotten coastal plain portion of ANWR is part of the refuge's 8 million acres legally protected as designated wilderness, accounting for about 42 percent of ANWR's total area.

A second misconception is that petroleum leasing and development would destroy the 1002 area. In reality, full leasing, development of three oilfields in succession, and production would affect less than 1 percent of the 1002 area's land surface by direct habitat removal and by secondary effects such as road dust from vehicle traffic or locally ponded water along roads (DOI 1987). Ninety-nine percent of the 1002 area would remain untouched. The area's habitats would not be altered sufficiently to affect the size, growth rate, or regional distribution of fish and wildlife populations. The only significant change would be aesthetic: over a period of decades, widely spaced roads, pipelines, drilling structures, and support facilities would be built on the open coastal plain. Structures would be removed when production ceased.

ARCTIC NATIONAL WILDLIFE REFUGE


BEAUFORT SEA
Prudhoe Bay
Kaktovik
ANWR COASTAL PLAIN
Trans-Alaska Pipeline
Canning River
Aichilik River
ARCTIC NATIONAL WILDLIFE REFUGE
U.S.A.
CANADA
Porcupine River
0
50
100 Miles
Scale
ARCTIC NATIONAL WILDLIFE REFUGE (ANWR) - 19 Million Acres
ANWR COASTAL PLAIN Section 1002 Study Area - 1.5 Million Acres
ANWR WILDERNESS AREA 2.3 Million Acres
KAKTOVIK INUPIAT CORPORATION ARCTIC SLOPE REGIONAL CORPORATION LANDS
Barrow
Prudhoe Bay
Kaktovik
ANWR
ALASKA
Anchorage

Source: ASRC 1986

FIGURE 1

A third widespread misconception about ANWR is that the 1002 area is somehow unique in relation to other parts of the Arctic Coastal Plain and that it contains landforms and biological resources not found on adjacent lands. In reality, ANWR wilderness lands to the east and south of the 1002 area include all geologic, terrain, habitat, and wildlife features found in the 1002 area.

This paper briefly examines these misconceptions and explains why all three are unfounded.

ANWR's Wilderness Lands

The 1002 area in its entirety is only 8 percent of ANWR's surface area (Fig. 2). The remaining 92 percent of ANWR is protected as either designated wilderness or refuge lands. Forty-two percent of ANWR, about 8 million out of its 19 million acres, is a unit of the National Wilderness System. ANWR's designated wilderness area is a vast, continuous block of undeveloped terrain comprising entire mountain ranges, glaciers, river systems, forests, wetlands, and coastal plain. The coastal plain component of the ANWR wilderness unit encompasses five river drainages and extends for more than 30 miles from the eastern boundary of the 1002 area (the Aichilik River) to the U.S.-Canada border (Fig. 3). However, wilderness does not stop at the border. Immediately to the east lies Canada's 3-million-acre Northern Yukon National Park, providing a continuum of protected wilderness stretching to the Babbage River (DOI 1987).

In addition to its designated wilderness lands, ANWR contains another 9.5 million acres of refuge lands which, together with the ANWR wilderness unit, form a continuous undeveloped block of about 17.5 million acres, or 92 percent of ANWR's total area (Fig. 2). As noted recently by the Secretary of the Interior, about 55 million acres of federal land in Alaska are set aside and protected as designated wilderness, and an additional 80 million acres are managed as national parks, preserves, wildlife refuges, and other conservation units (DOI 1987). Only about 1.5 million acres are included in the 1002 area. Yet potentially enormous

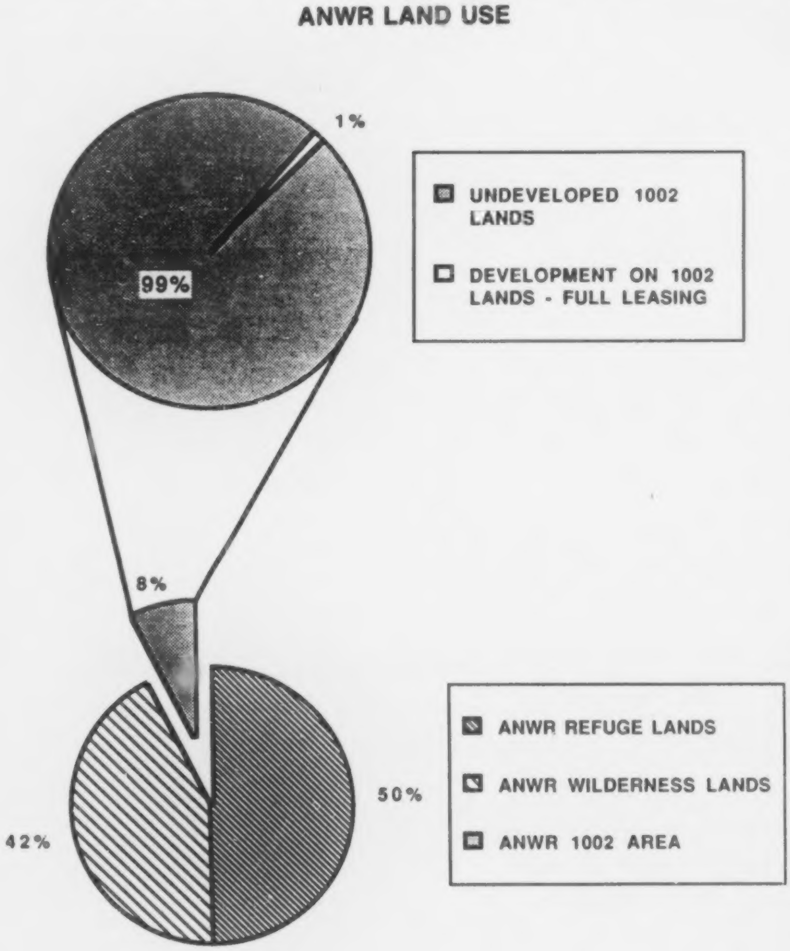

ANWR LAND USE
1%
99%
UNDEVELOPED 1002 LANDS
DEVELOPMENT ON 1002 LANDS - FULL LEASING
8%
50%
42%
ANWR REFUGE LANDS
ANWR WILDERNESS LANDS
ANWR 1002 AREA

FIGURE 2

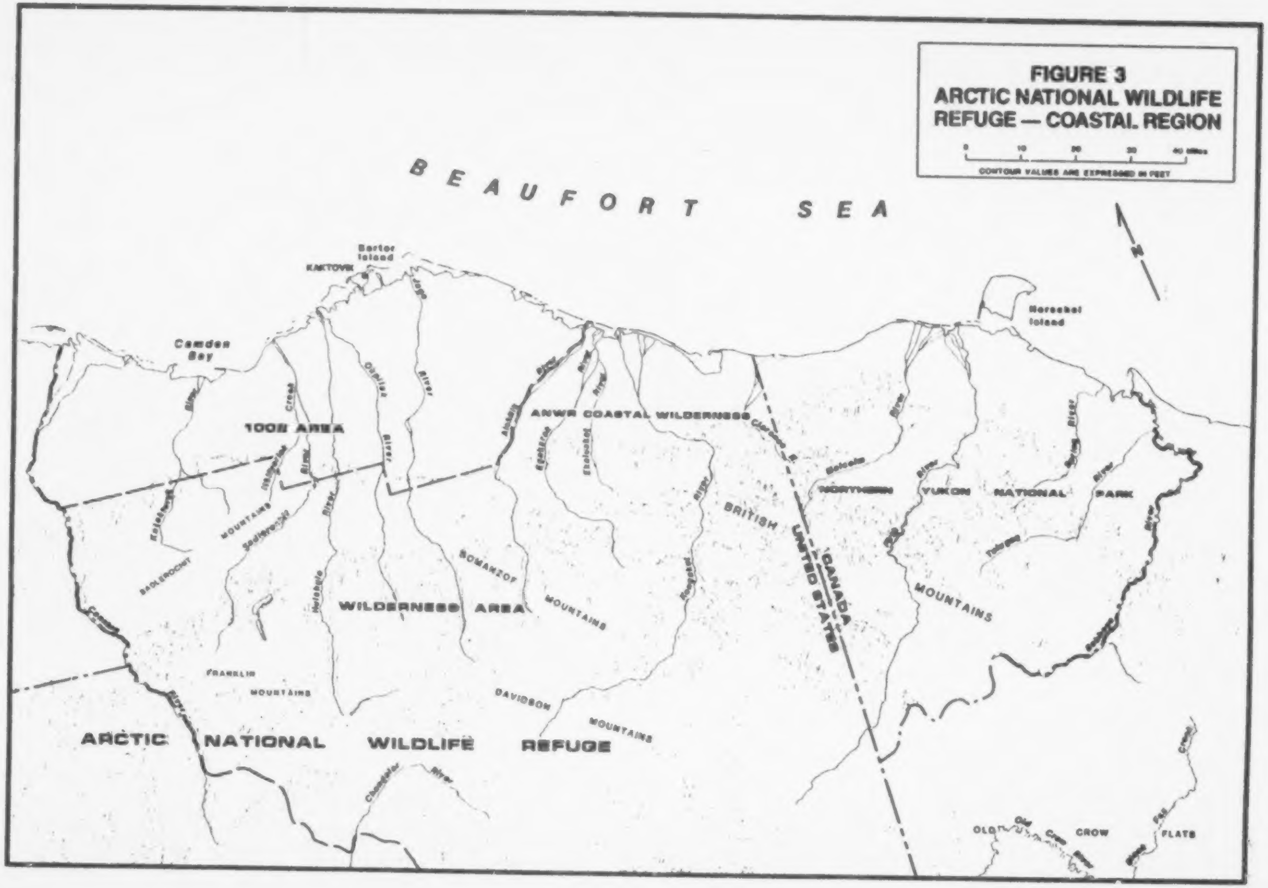


FIGURE 3
ARCTIC NATIONAL WILDLIFE REFUGE — COASTAL REGION

petroleum reserves may exist beneath this tiny fragment of Alaska's protected conservation lands.

1002 Area Development

In the Final ANWR Coastal Plain Resource Assessment and Legislative Environmental Impact Statement, the Department of the Interior (DOI) estimated that the 1002 area could contain up to 9 billion barrels of recoverable oil. This quantity is equivalent to the Prudhoe Bay oilfield, which currently provides one-fifth of U.S. domestic oil production (DOI 1987).

Congress is now approaching a decision on whether to allow oil and gas leasing within the 1002 area or to protect the tract from exploration and from potential development and production of resultant discoveries. As the public, industry, environmental groups, and legislators evaluate this issue, it is important to remember that development of three large oilfields in the 1002 area would directly cover only about 5,650 acres. An additional 7,000 acres would be modified by secondary influences such as dust deposition, local ponding of water along roads, etc. (DOI 1987). In total about 12,650 acres would be affected by full leasing, development, and production (Fig. 2). This amounts to less than 0.08 percent of ANWR's total 19 million acres. Congress must decide whether the preservation of 0.08 percent of ANWR's surface area is worth forgoing exploration and potential development of what may be the largest remaining oil and gas reserves in the United States.

The Protected ANWR Coastal Wilderness

The ANWR coastal plain east of the 1002 area has been preserved for its wilderness values and is ideal for recreation. A land of immensity and beauty, its landscape is more complex and visually interesting than that of the 1002 area. Furthermore, it includes examples of all landform features, habitat types, and fish and wildlife species found in the 1002 area. Thus the 1002 area is not unique with respect to scenic and biological resources. The true uniqueness of the 1002 area is more likely its petroleum resource potential.

Landforms. The ANWR coastal wilderness includes the full range of landforms and terrain features found farther west in the 1002 area. These include unglaciated uplands, glacial moraines and till, oriented lake terrain, glacial outwash plains, and other features (Table 1). The feature probably most influential in forming coastal terrain in the ANWR wilderness area is the glacial gravel outwash plain. Both in the 1002 area and in the ANWR coastal wilderness, gravel outwash plains were formed during the Pleistocene period by rivers draining the glaciers that covered most of the area. These fan-shaped gravel plains, now covered by tundra vegetation, are nearly flat and cover about 15 percent of the coastal plain portion of ANWR. Within the ANWR coastal wilderness, impressive gravel outwash plains are associated with five major river systems and cover about 75 percent of the land area (Table 1).

River Systems. East of the 1002 area are five large, braided rivers and numerous tributary creeks draining the Brooks Range. The rivers are, from west to east, the Aichilik, Egaksrak, Ekaluakat, Kongakut, and Clarence. With the exception of the Aichilik, which forms the eastern boundary of the 1002 area, the entire drainage systems of these rivers are inside the ANWR coastal wilderness and have formed broad alluvial fans along the Beaufort Sea coast. The rivers flow through a complete continuum of terrain and habitat types from the Brooks Range northward to the coast.

Coastal Lagoons. Coastal lagoons protected by barrier islands are common along the Beaufort Sea coast of Alaska and the Yukon Territory. Between Pt. Hope and the U.S.-Canada border, about 40 percent of the coast is of the barrier island/lagoon type (Fig. 3 and Table 1). Within the ANWR coastal wilderness, however, barrier island chains extend along all of the approximately 30-mile coastline, except for the 4-mile section east of Demarcation Bay. Included in these chains is 15-mile-long Icy Reef, the longest continuous barrier island in ANWR.

TABLE 1

LANDFORM FEATURES IN THE ANWR COASTAL WILDERNESS AND ELSEWHERE IN NORTHERN ALASKA

ANWR LANDFORM FEATURE	EXAMPLES IN ANWR WILDERNESS EAST OF AICHILIK RIVER	OTHER OCCURRENCES IN NORTHERN ALASKA
Outwash Plains	Egaksrak, Ekaluakat, Kongakut river valleys	Canning, Sagavanirktok, Hulahula, Sadlerochit, Okpilak, and 15-20 other glaciated river valleys on the north side of the Brooks Range eastward of the headwaters of the Colville River
Arctic Slope Hydrological Systems	Egaksrak, Ekaluakat, and Kongakut river systems	Too numerous to list
Delta Sand Dunes	Kongakut and Egaksrak river deltas	Sagavanirktok, Kuparuk, Canning, Colville, Meade and numerous other river deltas
Offshore Islands	Almost all of the coast (about 85%)	About 40% of northern Alaska coast
Oriented Lakes	Egaksrak delta east of Demarcation Bay	Extremely common: Prudhoe Bay, Barrow, etc.
Non-glaciated Uplands	Divides between Aichilik and Egaksrak; Ekaluakat and Kongakut; and Kongakut and Clarence rivers	Very widespread across Arctic Foothills on north side of Brooks Range.

Biological Resources. Fish, wildlife, and habitats within the ANWR coastal wilderness are similar to those of the 1002 area. The Porcupine caribou herd typically migrates through and calves in the area every year (Roseneau and Curatolo 1976, DOI 1987), and use by most species of nesting birds and staging waterfowl appears to be similar to that in coastal plain areas farther west (Tull et al. 1974, Koski 1977). The ANWR coastal wilderness contains numerous anadromous fish streams and a limited number of fish overwintering pools that remain partially unfrozen through the winter (Craig and McCart 1974).

Conclusion

This paper has made three important points concerning oil and gas leasing of ANWR's 1002 area:

1. The 1002 area does not include the entire coastal plain of ANWR. Between the 1002 area and the Canadian border are 450,000 acres of legally protected coastal plain wilderness contiguous with the remaining 17.5 million acres of protected refuge lands within ANWR. Nearly half of those protected lands, about 8 million acres, are a unit of the National Wilderness System.
2. Full leasing, development of three oilfields in succession, and production of potential reserves would affect less than 1 percent of the 1002 area's land surface by habitat removal and secondary effects (DOI 1987). The remaining 99 percent would remain untouched. This small extent of alteration would not significantly affect fish and wildlife populations. The only real change would be aesthetic: the visible presence of oilfield facilities which would be removed when production eventually ceased.
3. The 1002 area is not unique. Other parts of Alaska's Arctic Coastal Plain have similar landforms, scenic resources, and habitats, including the ANWR coastal wilderness east of the 1002 area. The true uniqueness of the 1002 area is more likely its petroleum resource potential.

Congress must decide whether it is worth forgoing the potential benefits of what may be the largest remaining oil and gas reserves in the United States in order to preserve the aesthetic value of the 1002 area, which is less than 8 percent of ANWR and similar to adjoining coastal lands already protected as wilderness.

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